The Annual Convention will be held at Rochester, N. Y., September 30, October 1, 2 and 3.

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1923—1924.

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A Member shall be an officer or employee of a public or private water works, an engineer, chemist or other person qualified to aid or interested in the advancement of knowledge relative to water works.

An Honorary Member shall be a person of acknowledged eminence in some branch of water supply or of engineering.

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An Associate shall be either a person, firm or corporation engaged in manufacturing or furnishing materials or supplies for the construction or maintenance of water works.

A Corporate Member shall be either a Water Board, Commission, Company or Municipal Corporation.

The initiation fees and annual dues are as follows:

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This Association has six regular meetings each year, all of which, except the annual convention in September, are held at Boston.

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YEARS 1900-1923 INCLUSIVE

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New England Water Works Association

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This Association, as a body, is not responsible for the statements or opinions of any of its members.

MECHANICAL FILTRATION PLANT AT PUTNAM, CONNECTICUT.

BY FRED O. STEVENS.*

The original water system for the city of Putnam, Conn., was built in 1885 by the Putnam Water Company, under the direction of William Wheeler as consulting engineer. Little River, the source of supply, receives run-off from the towns of Woodstock, Pomfret, Putnam, Thompson and Southbridge; the watershed having an area of 38 square miles and including the villages of North Woodstock, East Woodstock, Woodstock and Sprucedale and a large area of farming land. It also includes a considerable swampy area and two ponds, Sprucedale Reservoir and Woodstock Pond, the largest of which, Woodstock Pond, has been used for years as a pleasure resort, with boating and bathing allowed.

Sanitary conditions on the watershed are bad; its size and value, together with the importance of the villages as residential centers, preclude any possibility of purchase by the city and render difficult, if not impossible, any adequate system of sanitary control.

Conditions were probably little, if any, better when the works were built, but water was delivered to consumers without treatment until 1906, when the company built a slow sand filter plant consisting of three beds with a combined area of one fourth of an acre and a clear-water basin holding about 200 000 gal., all of the usual groined arch construction.

In October, 1913, the works were taken over by the city and by 1914 the consumption had reached an average of 950 000 gal. per day with a maximum of 1 500 000 gal. or over, so that it became necessary at times of peak consumption, and when one bed was out for cleaning, to supplement the filtered supply with raw water. As this raw water showed consistently a high bacterial count (1 000 to 58 000 at 37.5 C.), with *B. coli* nearly always present, a chlorinating outfit was installed which accomplished bacterial removal very effectively. The supply, however, had at times a very high color, — so high that even after passing the slow sand filters its appearance was distasteful to the consumers.

*Water Supply Engineer, Boston, Mass.

Studies were made at this time for the construction of additional slow sand units, but due to the topography in the vicinity of the plant the cost per acre figured abnormally high. Taking into account this feature of high first cost, the high cost of scraping resulting from the large amount of sediment and vegetable matter carried in suspension, and the fact that

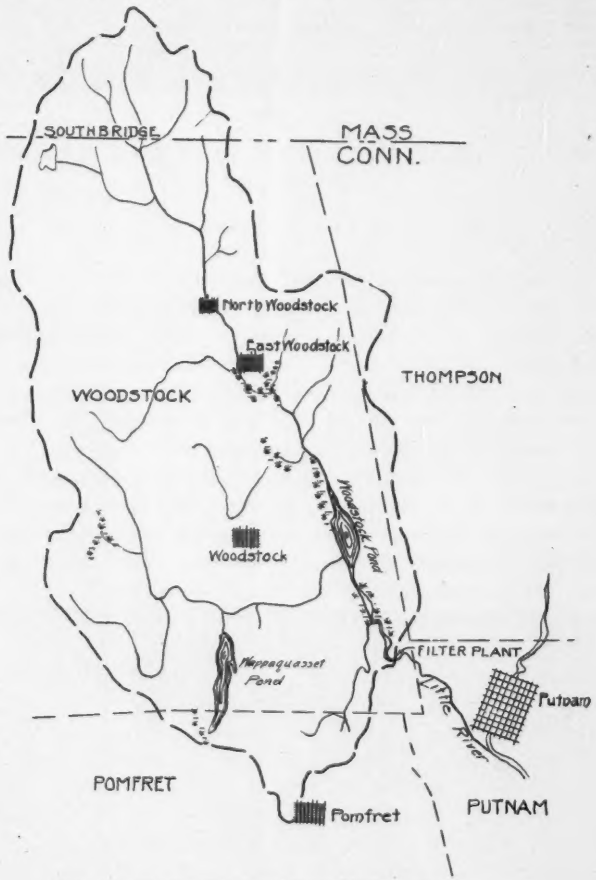
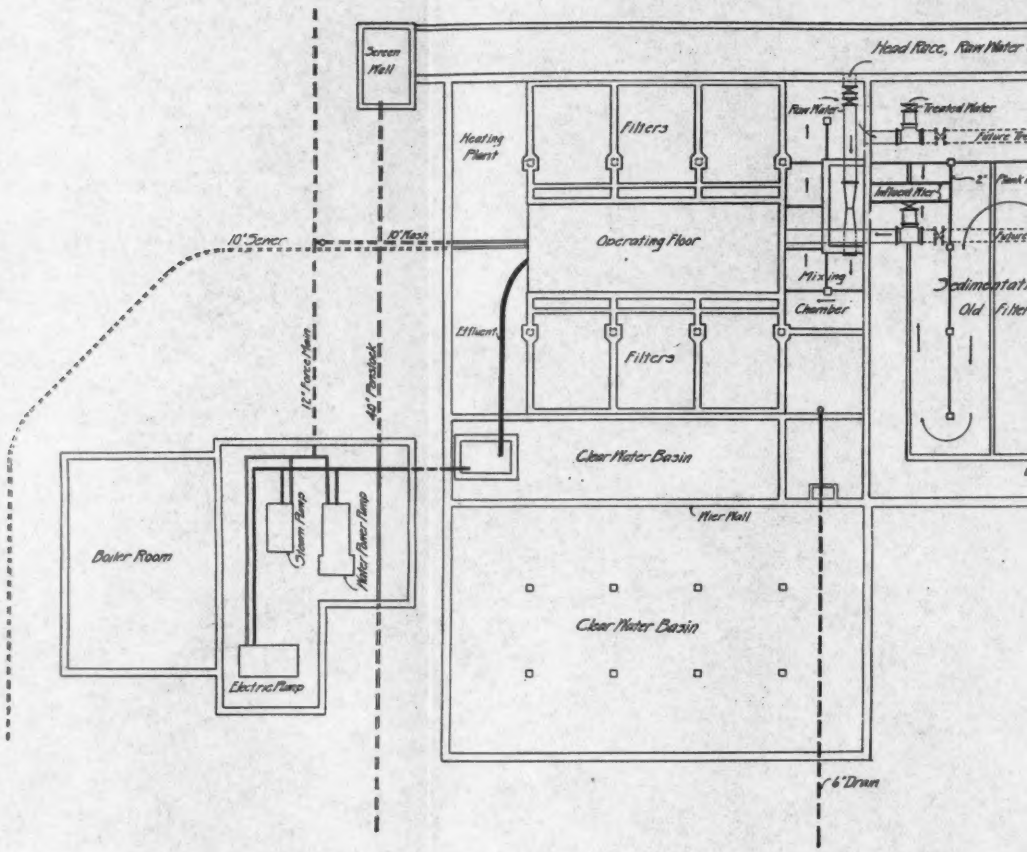


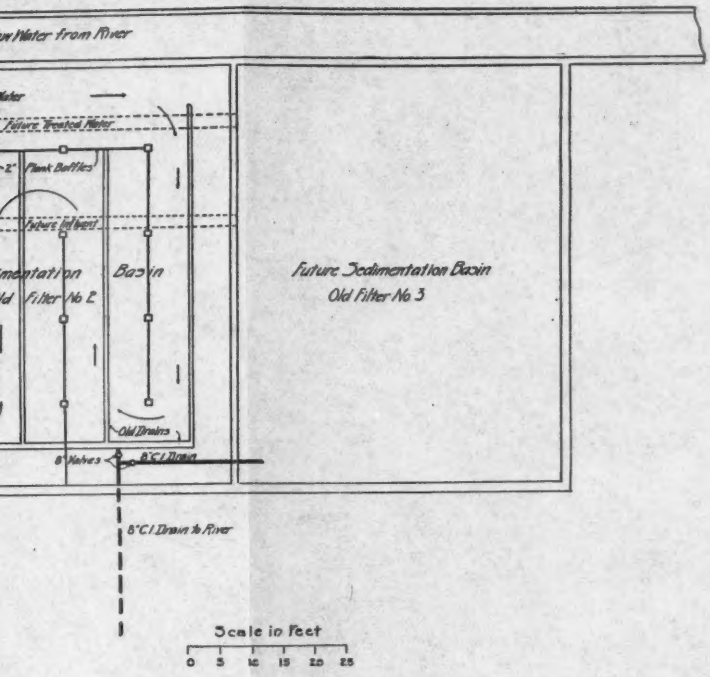
FIG. 1.— WATERSHED OF LITTLE RIVER ABOVE FILTRATION PLANT.

with slow sand filtration the effluent would at times have a color of 50 p.p.m., it appeared that coagulation with alum and mechanical filtration would be the logical method of treatment.

Owing to war conditions and the necessity of financing other improvements to the system, no definite steps towards construction were taken until the summer of 1922, when, after receiving from the Norwood Engineer-



GENERAL PLAN OF FILTRATION



PUTNAM FILTERS
1923
Henry A. Symonds, Fred O. Stevens
Engineers

TION PLANT.

ing Company a tentative plan and estimate for an extremely low-priced mechanical plant, the Board of Water Commissioners engaged Henry A. Symonds and the writer as engineers, to design and supervise the construction of a suitable modern plant. Harry W. Clark, Chief Chemist, Massachusetts Department of Public Health, acted as consultant on certain features of the problem.

In August, 1922, the City Council, acting on the engineers' preliminary report and estimate, authorized the expenditure of $35 000 then in the treasury of the Water Department; this, with some current receipts, making about $40 000 available.

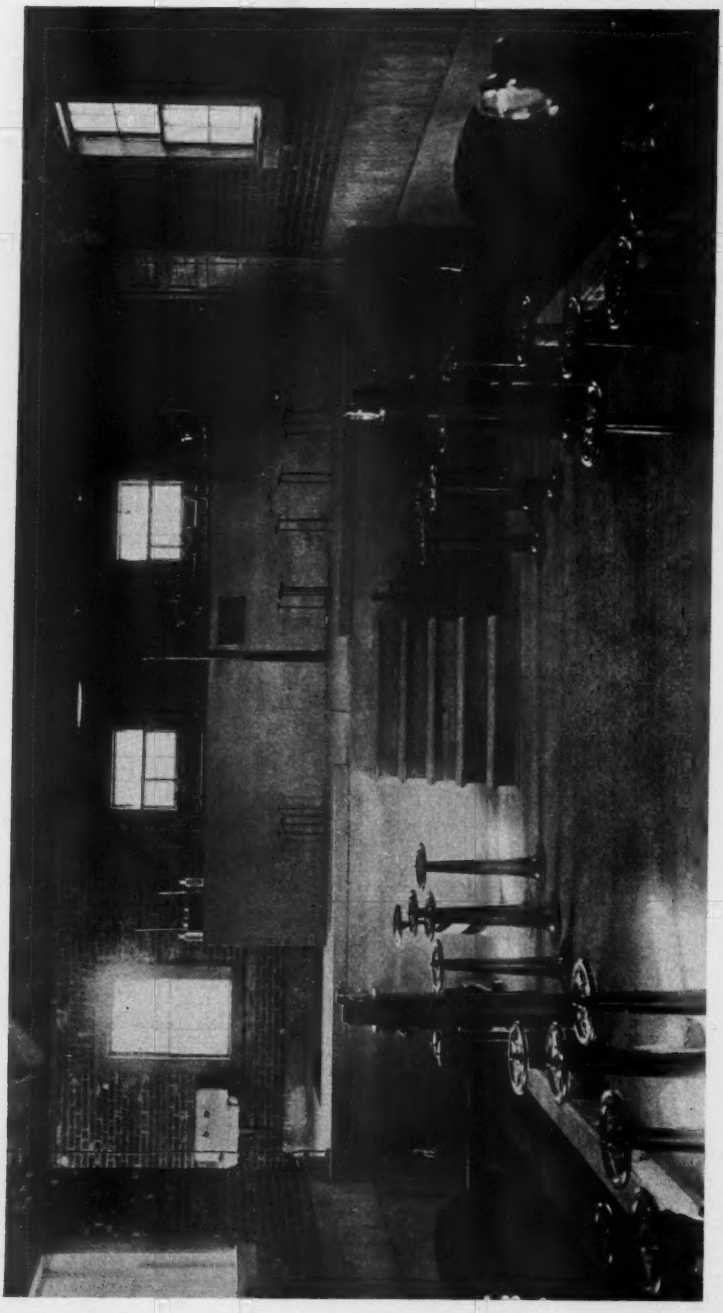
The building of this plant is part of an incompleted program of rehabilitation which is a severe tax upon the finances of the Water Department; a situation demanding a plant capable of furnishing a first-class effluent, of sufficient capacity for present needs and with provision for economical enlargement; all at the very lowest possible price consistent with permanence and efficient operation.

To attain these ends it was necessary to make the greatest possible use of the existing structures, and to eliminate from the equipment all apparatus, such as gages, operating tables, etc., not absolutely essential to the operation of the plant. Existing structures were utilized by placing the filter units, pipe gallery, chemical mixing and feeding apparatus and heating plant in old filter No. 1, using filter No. 2 as a coagulating basin, with filter No. 3 in reserve and the old clear-water basin for filtered water storage.

The chief difficulty in making full use of the old structures arose from the fact that the full-water level in the old clear-water basin was but 2.5 ft. lower than the normal level in the pond and head race, which determines the height of water on the filters. By constructing a sump in the clear-water basin it was possible to obtain a maximum operating head of ten feet, which will give a discharge from the filters in excess of the capacity of the present pumping-plant, if the beds are washed with reasonable frequency. This condition involves more frequent washing than would be necessary with higher operating head, but as a great part of the pumping is done with water power that would otherwise be wasted, the extra cost of wash water is not of great importance. It was decided, therefore, to build the plant to operate under this low head, for the present at least, and save the cost of a new clear-water basin for other much-needed improvements.

General Arrangement of Plant.

Old filter No. 1, adjoining the clear-water basin, was of the usual type of concrete construction with groined arch roof, divided by the roof columns into twenty 12-ft. x 12-ft. bays, five bays in length and four in width. The new filter beds, six in number, were placed in the twelve central bays, leaving four bays across the south end for chemical mixing and application, and four across the north end for heating plant, coal



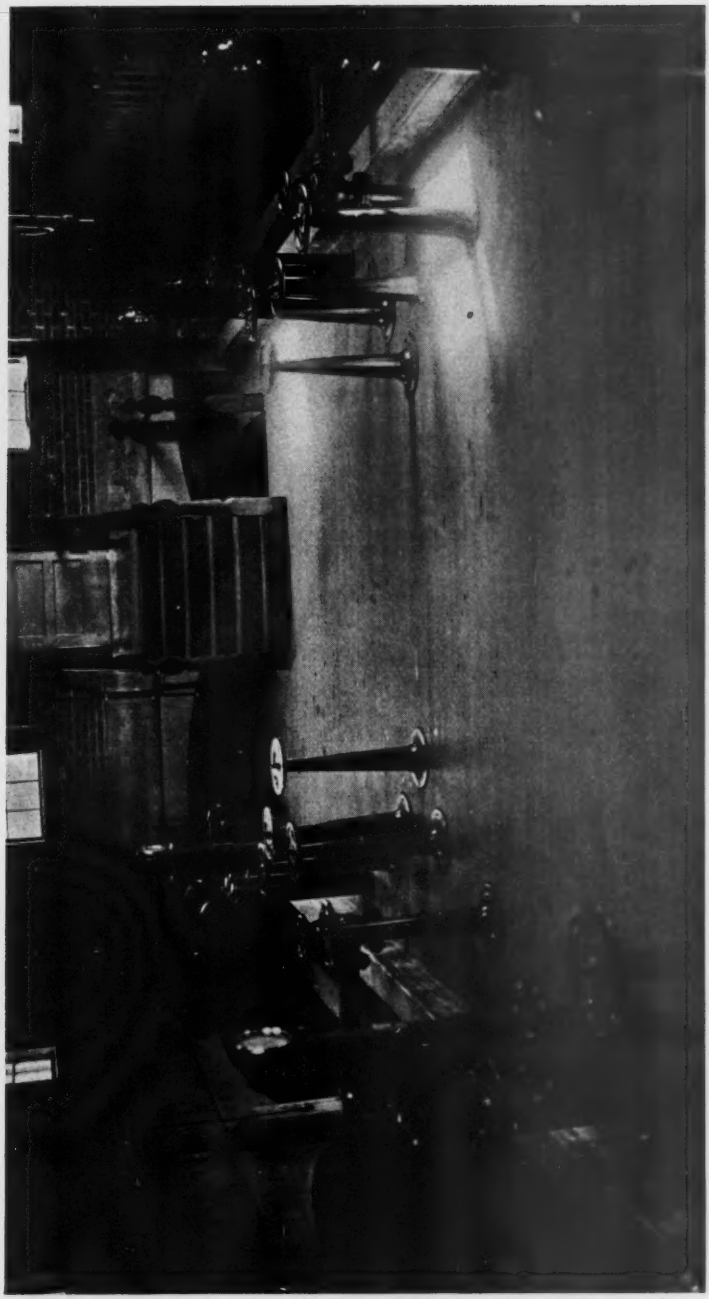


FIG. 2.—VIEWS OF FILTER HOUSE INTERIOR SHOWING OUTLINE OF OLD GROINED ARCHES.

storage and various mains leading from the pipe gallery. The beds are arranged three on either side of a central pipe gallery 38 ft. x 13 ft. with operating floor over the gallery.

The operating floor, chemical room, and a portion of the beds are covered by a plain brick superstructure with 12-in. walls and a wooden hip roof. The old groined arch roof originally covering this area was removed and the new structure carried on reinforced concrete beams supported by the old roof columns.

In the four end bays assigned to chemical apparatus are located the mixing-chamber, automatic feed devices, chemical tanks and laboratory bench and sink. Adjoining the mixing-chamber is coagulating basin No. 1, formerly slow sand filter No. 2, which in turn joins basin No. 2, formerly filter No. 3, to be used as a spare while No. 1 is out for cleaning, or in conjunction with No. 1, if longer sedimentation period is needed.

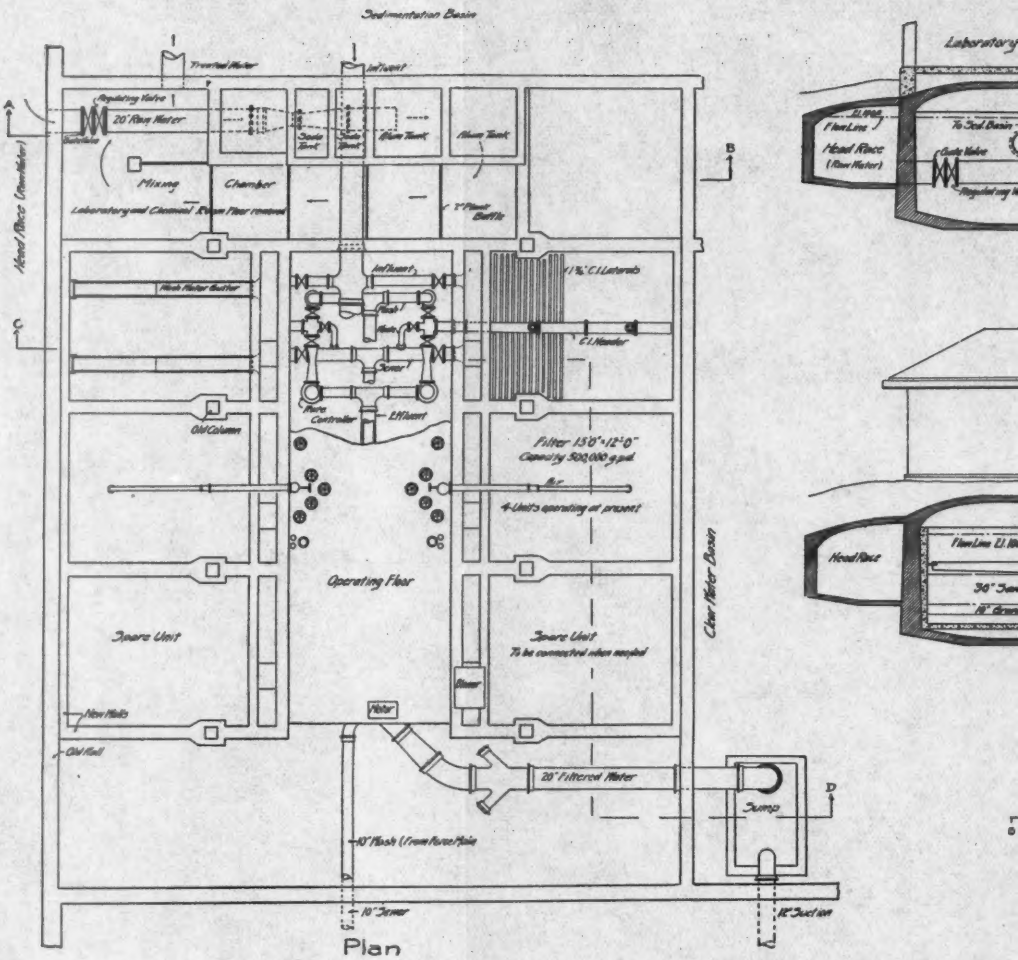
The heating plant with coal storage, etc., situated in the easterly four bays of old No. 1 filter, is under the old groined arch roof which was not removed, and is reached by stairs from the operating floor to the pipe gallery.

Chemical Application and Sedimentation.

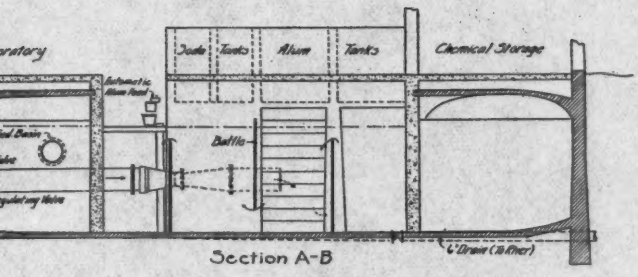
The raw water enters the plant from the head race through a 20-in. cast-iron main, passing directly under the chemical tanks from which it receives the chemical dose by gravity. In this 20-in. line is located a 20-in. x 10-in. venturi tube, controlling the alum feed and a 20-in. float controlled hydraulic valve for regulating the height of water in the coagulating basin and on the filters. From the venturi the treated water passes through a concrete mixing-chamber located under the floor of the chemical room and leading directly to the 20-in. valve opening into the coagulating basin. This chamber is 6 ft. wide and about 53 ft. long, and is subdivided by a series of 2-in. plank baffles of the over-and-under type, giving a mixing period of about twelve minutes when operating at 2 000 000 gal. per day. The design allows for increasing or decreasing this period by a simple rearrangement of the plank baffles.

Alum and soda tanks are of reinforced concrete in duplicate, each tank holding sufficient solution for about two days' run under normal conditions. Alum tanks are equipped with water-motor-driven agitators, but as soda is used only on rare occasions agitators were omitted on the soda tanks.

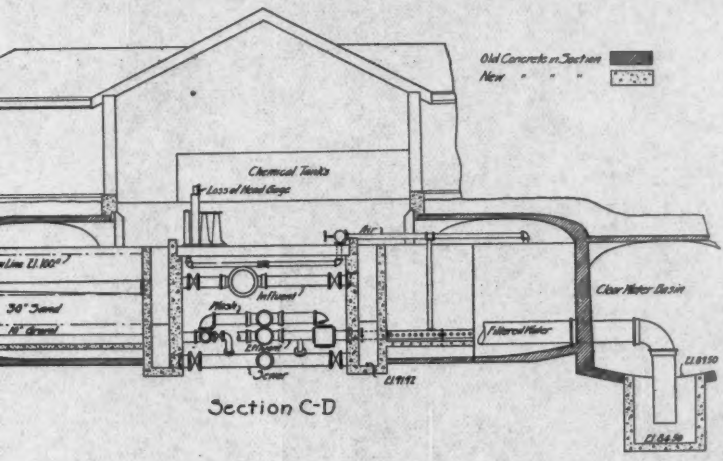
Owing to the varying rate of filtration resulting from the variable operating head due to rise and fall of water in clear-water basin, it was necessary to provide automatic feed for the alum solution, and this was accomplished by means of special apparatus designed by The New York-Continental-Jewell Filtration Co., consisting essentially of a needle valve having its opening controlled by the differential pressure at the venturi tube in the raw-water line. The soda feed is of the manually operated



PLAN AND SECTIONS OF FILTE



Section A-B



Section C-D

Scale in Feet
0 1 2 3 4 5 6 7 8 9 10

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Engineers

orifice type requiring occasional adjustment by the operator during the infrequent periods when soda is being used.

The coagulating basin, 51 ft. x 64 ft., is so divided by 2-in. plank baffles of the around-the-end type as to form a channel 12 ft. wide and 230 ft. long from the treated water inlet to the settled water outlet, affording a settling period of a little less than two and one half hours when filtering at the 2 000 000 gal. rate. At the present maximum rate of about 1 600 000 gal., this gives about three hours sedimentation, which is apparently sufficient, but the plan provides for the use of old filter No. 3 as a coagulating and sedimentation basin in conjunction with the present one, making it possible to double the coagulating and settling period if necessary. At the outlet of the basin the settled water passes over a skimming weir into the 20-in. cast-iron pipe leading directly to the forebays in front of the filters.

Filters.

The filters, six in number, are reinforced concrete boxes, 12 ft. x 15 ft., inside dimensions, giving, at the usual rates prescribed for mechanical filtration, a daily capacity of 500 000 gal. per unit. They are built, three on either side of the central pipe gallery, with their bases resting directly on the floor of the old slow sand filter.

The collecting system is of standard type for low velocity wash with air agitation, consisting of cast-iron headers with cast-iron laterals and brass strainers, all imbedded in concrete. The filtering medium consists of 10 in. of graded gravel and 30 in. of sand having an effective size of 0.42-mm. and a uniformity coefficient of 1.51.

Each unit is equipped with a Simplex effluent controller and loss of head gage. Wash water is supplied directly from the force main through a valve outside the plant, permanently throttled to give the proper maximum wash-water velocity.

Air is supplied by a rotary blower, driven by a 15 h.p. electric motor, all located on the operating floor.

Construction.

The structural portion of the plant was built by the city on force account, under the supervision of the writer, and The New York-Continental-Jewell Filtration Co. of Nutley, N. J., were contractors for the filter and chemical equipment.

As it was necessary to throw two of the old slow sand units out of operation at the beginning of construction, it was decided to do the work during the winter months when the city's consumption was lowest and the quality of the water at its best. Work was commenced about December 1, and carried through the months of December, January and February, with some interruptions due to delay in receiving materials. Concrete was poured at all temperatures, sometimes at very near the zero mark. The

mixer was at all times operated with a Hauck burner which produced a mixture steaming hot as it entered the forms, and new work was protected for at least two days by canvas and salamanders.

The mix, varying considerably with the character of the aggregate, averaged about 1 : 2 : 4 for the entire job. No frost-proofing or water-proofing compounds were used, but special attention was given to grading the aggregate for maximum density and to regulating the water to obtain the proper consistency. In addition to these precautions, perfect puddling was insisted upon and the resulting concrete was water-tight and satisfactory in every respect.

Operation.

The filters have been in operation since September 15, 1923, and no unusual difficulties have been encountered. Color of raw water has varied from 25 to 80 p.p.m., alum dose from ½ to 2 grains per gal. with an average of about 1 grain per gal., and filtered water color has been held at about 10 p.p.m. Removal of color below 10 p.p.m. has not been attempted, as an effluent of that color is, in the eyes of the consumers, colorless, and it does not seem advisable to establish a lower color standard which may, at times, be difficult to maintain.

Soda has been used during periods of combined low alkalinity and high color, due to the heavy rains of the fall of 1923. The average dose has been about 0.3 grain per gal.

Due to the low operating head the amount of wash water used has been rather high, averaging about four per cent, but, as previously stated, this is not an important factor on account of the low cost of wash water.

Sedimentation has been very effective and, with the auxiliary basin available for extreme conditions, should prove one of the best features of the plant.

The original duplicate chlorinating outfit was retained, applying chlorine after filtration, the water in the past having shown dangerous pollution so consistently that at least two lines of defense seemed necessary to insure safety.

Summary.

This plant embodies nothing especially new in design or construction and is interesting chiefly on account of the use made of the old structures in the new design, and the fact that the city obtained thereby a new and efficient mechanical plant of 3 000 000 gal. capacity at a total cost of $41 000, or a little less than $14 000 per mil. gal. The total cost, moreover, was less than the estimated cost of bringing the old slow sand plant up to 2 000 000 gal. capacity, while the new mechanical system is able to remove color, to the satisfaction of the consumers.

CURRENT PRACTICE IN CHARGES FOR PRIVATE FIRE PROTECTION.

BY H. A. BURNHAM.*

[*Read March 11, 1924.*]

In our work of fire protection for manufacturing properties our Inspection Department is often called on for advice regarding the fairness of a certain charge for connection to an automatic sprinkler system, and in connection with these questions we have found such wide variations in practice that we have attempted further inquiries into the reasons for them. In the latter part of 1922 a questionnaire was sent out to most of the Water Departments protecting properties insured in the Mutual Companies, with the following results:

Replies were received from 259 cities and towns in 18 States, including the New England States, Middle Atlantic States and the Mid-western States north of the Ohio River. The information is tabulated as follows, placing the States in the order of the degree of recognition of this service as a beneficial one, as shown by the absence of the annual charge:

State	Number Replying	Number Making no Charge	Municipally Owned		Privately Owned	
			Making no Charge	Making some Charge	Making no Charge	Making some Charge
Massachusetts	46	42	38	4	4	0
New York	32	23	21	8	2	1
Connecticut	27	15	10	4	5	8
Ohio	23	13	13	7	0	3
Pennsylvania	29	11	11	4	0	14
Wisconsin	22	8	7	11	1	3
New Hampshire	13	7	7	3	0	3
Michigan	11	7	7	4	0	0
New Jersey	14	5	5	2	0	7
Maryland	4	3	3	1	0	0
Maine	11	2	2	7	0	2
Rhode Island	6	2	1	2	1	2
Delaware	2	2	2	0	0	0
Iowa	4	2	2	1	0	1
Vermont	3	1	1	1	0	1
Illinois	2	0	0	1	0	1
Indiana	9	0	0	6	0	3
Minnesota	1	0	0	1	0	0
	259	143	130	67	13	49

It is interesting to note that no annual charge is made by 66 per cent (130) of the municipally owned systems and by 21 per cent (13) of the pri-

* Engineer and Special Inspector, Associated Factory Mutual Fire Insurance Companies.

vately owned systems, and that no annual charge is made by 55 per cent (143) of all from whom replies were received. In other words, more than one-half of those reporting make no annual charge; and this fact alone indicates that there is a very general recognition of the difference between a connection for industrial use and one for fire service only.

It will also be noted that the water departments, as shown in the first three States in the table, number 80, or well above one-half of the total in this column, and in these three States are nearly all of the private companies reporting making no charges for this service. These States will be recognized as the pioneers in manufacturing industries.

Analyzing further the cases where some charge is made, we find the basis on which charges are made is about the same for municipally and privately owned systems, namely:

$\frac{1}{3}$ base a flat charge on diameter of the pipe connection;

$\frac{1}{3}$ base a charge on the number of hydrants or sprinkler heads;

$\frac{1}{3}$ use a flat rate for some special combination of the number of sprinkler heads, hydrants and pipe sizes.

The extremely wide range in these charges in dollars is shown as follows:

Basis of Charge	Municipally Owned	Privately Owned
Per hydrant	\$20.00 to \$50	\$10 to \$75
Size connection		
4	\$7.50 " \$96	\$50 " \$260
6	\$7.50 " \$180	\$75 " \$600
8	\$12.50 " \$300	\$200 " \$1 000
Per sprinkler head	½c. " 25c.	5c. " 25c.

It is of course impossible that all these charges, varying through such wide extremes, are equally fair. It is quite generally agreed that the charge for service to a private fire system should be based on the cost of service.

The Committee of this Association on this subject close their report (*Journal* of September, 1919) with the words " We strongly urge that in all such cases [seeking of additional revenue] costs of service should be considered and that in any new schedules rates should be based on costs."

The National Fire Protection Association at the Chicago Convention in 1923 accepted as part of the report of the Committee on Private Fire Supplies from Public Mains, a report on Charges for Private Fire Services, which has been reprinted and is ready here for distribution to those who desire copies. That report states briefly the functions of the water systems, defines Public and Private Fire Services, quotes some findings of Commissions' reports and committees pointing to the justice of basing charges on costs, and describes some of the public benefits from private equipments. The report is summarized as follows:

1. One of the functions of a water-works system is to supply water for fire protection. There can be no just discrimination between public and private fire protection if the ultimate purposes of these services are identical.

2. Every taxpayer, from the owner of the smallest house to the owner of the largest factory or mercantile property, is entitled to the protection furnished by the water and fire departments.

3. If the taxpayer elects to take his fire protection through appliances of his own, in order to protect his property in a more efficient manner than the municipality can afford to do it, he is still entitled to his fire protection on the same basis as the other taxpayers.

4. The charge for private fire service should be based on the cost of producing and delivering that service.

5. On the basis of fact and experience the actual cost of private fire service may be expressed thus:

Item A. A definite sum representing the general tax payment of the user.

Plus Item B. A definite sum representing interest, depreciation, maintenance and inspection costs of the pipe connections for private fire services.

Plus Item C. A variable or indefinite sum representing any elements of cost not already included in Items A and B and which is zero under ordinary conditions.

6. The charge should be paid by those who benefit by the service.

7. Private equipments relieve the community of part of the fire-fighting demands it would otherwise have to meet and so play a most important part in the fire-extinguishing function of the water supply.

8. In a community where average conditions exist, the application of these principles would not involve any stand-by charge for sprinkler service above that already paid for general fire protection through taxes.

In compressing such a complicated matter into such a small compass as this summary, the fundamental features have been stressed, as they are often lost sight of or overshadowed by minor questions. One of the most common of these questions asks why the water department should not collect something more from the sprinkler owner if the water department makes it possible for the sprinkler owner to obtain cheaper insurance. The benefit of low insurance rates obtained by owners of private fire protection systems has nothing to do with the question, as is sometimes supposed, because the point under discussion is fire *protection*, and the lower rates are merely incidental to it; therefore, to allow a high charge for fire protection service because the owner is fortunate enough to enjoy a low rate on account of it, would seem almost confiscatory.

Another troublesome feature is the fear of charges of discrimination if a fire-service class is recognized, and lower than industrial rates are allowed for it. We believe it can be shown that the discrimination already exists in many cases because whoever owns and maintains a sprinkler equipment or a fire pump with private hydrants, or both, contributes something very definite to general fire protection for which all who are benefited thereby do not usually pay.

Commenting on the various bases on which the charges are found to be made, the use of the size of the connection is least open to criticism, while the use of the number of sprinklers as a basis of charge is most objectionable.

If the charge is based on the number of sprinklers, a penalty is thus imposed on the most effective means of fire protection known, and installations of sprinkler equipments are discouraged. It means the more sprinkler heads a property owner has, the more he must pay the water department for fire protection. If his entire property is sprinklered the number of sprinkler heads is proportional to the floor area and so approximately proportional to the value of the property; but as the usual property tax is also based on the value of the property, the placing of a special fire-protection tax on this same basis appears like double taxation. This apparent injustice would seem still further pronounced in cases where municipalities may compel by law the installation of sprinklers in places where people may assemble, such as theaters, schools, factories or stores.

As to the use of the number of hydrants as a basis for charge, this practice is doubtless the result of a long-standing custom of making charges for fire service to municipalities where a part of the cost of the general fire protection is that of maintaining the hydrants, and as this part of the cost is proportional to the number of the hydrants, this basis is fair for this part as long as the water department provides and maintains the hydrants. Where the hydrants of the private fire equipments are owned and maintained privately, however, as is generally the case, a charge by the municipality for maintaining them is of course not fair.

Eliminating as unsound the practice of basing a charge on the number of sprinklers or hydrants, the remaining prevailing basis is that of the size of the connection. This basis appears the most reasonable. The cost of the pipe and controlling devices on it which may be owned and maintained by the municipality, between the street main and the protected property, is proportional to its size, and a nominal charge to cover interest, depreciation and maintenance of these is just. Such a charge is not so large as to be a deterrent to the installation of adequate protection of life and property through automatic sprinklers.

The question may arise as to why, in this argument, use is not made of the delivering capacity of the outlets afforded by the hydrants and sprinklers. The answer is that in the first determination of the capacity requirement for general fire service it is assumed and expected that the maximum delivery capacity of the public system as a whole will be used, if necessary, to extinguish any fire, whether in sprinklered or unsprinklered property. No public system could possibly supply water at serviceable pressure to all the hydrant and sprinkler outlets on it; and therein lies the difference between the demands of fire service and of industrial service. In the latter the system must continually supply water to all its outlets. In the fire service this is impossible.

Discussion.

Mr. Stephen H. Taylor.* My ideas more or less correspond with Mr. Burnham's. I believe that one of the things that a city is bound to do is to furnish all property with fire protection, and a most important part of fire protection is the water supply. I believe that the owner of a factory, or whatever the building is, who installs sprinklers reduces the labor of the fire department and the quantity of water required for putting out the average fire in that building. Therefore, it seems to me that if a building owner pays the whole expense of installing the automatic sprinkler supply, including double check valves, and the cost of inspection and maintenance of the same, that is all he should be required to pay.

Of course another feature which should not be lost sight of is the fact that sometimes a system put in for fire protection is used, either surreptitiously or unbeknown to the owner, by the engineer for water supply which should pass through the meter. That is an entirely different question from the one of charging for fire protection. But the two questions do come together sometimes when we find that water from the system put in without meters, for fire protection, is being used by the owner for purposes that should be metered.

Strictly speaking, I believe that there is no justification for any charge for fire protection with sprinklers or private fire hydrants, provided the owner of the property installs and maintains the equipment at his own expense, using it for fire purposes only.

Mr. Theodore L. Bristol.† Mr. Burnham indicates that the absence of an annual charge for connection to an automatic sprinkler system is recognition that this service is beneficial. If this is so, an annual charge would indicate that the service is not recognized as beneficial.

The facts as an economic or commercial proposition appear practically just the opposite. If one is furnished anything of value he usually expects to pay for it. If one furnishes anything of value to another person, especially if it costs anything to furnish it, the one who gives the service expects to be paid for it.

No one will deny that a water works is not only built for domestic and industrial services but also for fire protection service — sometimes the latter amounts to half the cost of the plant.

The trouble is and has been that this fact has not been given proper consideration in the fixing of rates. When water works have been placed in operation rates have been established based on those prevailing in nearby communities where the same rates may have prevailed for years, regardless of incidents or changed conditions.

The directors of the Ansonia Water Co., Ansonia, Conn., of which I am president, decided, a few years ago, to employ Mr. Nicholas S. Hill, Jr.,

* Superintendent, Water Works, New Bedford, Mass.
† President, Ansonia Water Co., Ansonia, Conn.

of New York, to value our plant and suggest a rate schedule. After careful study and thought, a rate schedule was prepared in which no recognition was given of any difference between a connection for industrial use and one for fire service only.

In passing, I will say that there are very few connections for "fire service only," as our experience has been that meters on fire services, when there have been no fires, have indicated considerable use or waste of water.

The schedule of rates adopted by the Company, and approved by the Public Utilities Commission of Connecticut, was approximately as follows: $\frac{5}{8}$-in. meter, $1.50 per quarter; 1-in., $5.40; 2-in., $18.00; 3-in., $43.50; 4-in., $63.00; 6-in., $118.50; 8-in., $190.50; 10-in., $216.00; the annual rates being four times these amounts. These are capacity or demand charges based on the ratio of each size meter to the $\frac{5}{8}$-in. meter as the unit.

Water used is charged in addition according to the following schedule:

First	10 000 cu. ft. per quarter	14½c.	per 100 cu. ft.
Next	90 000 " " " "	12c.	" " " "
"	150 000 " " " "	9c.	" " " "
"	250 000 " " " "	6½c.	" " " "

The question why the sprinklered owner should pay something for water-pressure service seems quite pertinent. The stand taken by Mr. Burnham, that it has nothing to do with fire protection, is illogical. Fire protection provided by water works is as much part of its business as is the provision for domestic and industrial use. If the water works should furnish fire protection free, why shouldn't insurance companies furnish insurance free? There is about as much reason in one proposition as in the other.

There are two questions I wish to ask Mr. Burnham. I think you spoke of the benefit that a sprinkler service gave to surrounding property. Do you know whether or not the insurance companies allow the insured any lower rate for that benefit?

MR. BURNHAM. Any lower rate to whom?

MR. BRISTOL. To owners of surrounding property.

MR. BURNHAM. I can't say as to that. I think it is safe to say that if there were a large number of plants similar to the condition in New Bedford, where several of the factories are connected together for mutual assistance by fire pumps, that there might be justice in making a lower rate for those immediately surrounding which are under the protection. I know a similar condition exists in Lawrence among the mills, where most of those mills can run hose from their own hydrants and protect the property of others. I should think there would be some benefit there.

MR. BRISTOL. We have that same thing in Ansonia. Years ago I remember, while we were furnishing the mills with water, the general opinion was that they were running pumps. We had quite a large fire on the main street and the firemen had very good pressure, and they spoke of

the pulsation of the pumps, that they could feel it, when we were furnishing this service on a gravity system. They just had an imagination.

MR. BURNHAM. They had another supply than the one they thought they were using?

MR. BRISTOL. Yes. They were on our supply, which was a gravity system. That is, we were furnishing the mills at the time although the mills did have pumps. Before we improved our system they could feel that pulsation, and they had better pump pressure on these fire hydrants, consequently they still thought they could feel that pulsation. But it was not so. My own experience is that there will be municipal hydrants out in the street, and then in a yard, within 50 feet, several mill hydrants, which is a big benefit to the community. But I do not think anything is allowed for it in insurance rates to other near-by property owners.

The other question I wish to ask is this: Did you get in your statistics how many fire services were metered?

MR. BURNHAM. I did, but not in this paper. That is another question. But, as Mr. Taylor says, they come together more or less. That is illustrated by the practice in the city of Newark. In the city of Newark the practice is that if you have a meter you have half the charge. That is, they put in the meter as a sort of insurance that the water will not be taken. I believe there is a double rate if there is no meter.

MR. JOHN C. CHASE.* This question of the charges for fire protection was pretty thoroughly thrashed out some sixteen years ago. I suppose there are less than a baker's dozen today who were present at the time the reports were made. A committee of nine was appointed, five of whom were insurance men and four were water-works men. As a result there were two independent reports, and the ninth man did not agree with either side.

I have seen nothing since then to change my mind in regard to charging for fire services. If a corporation is willing to go to a large expense in installing a sprinkler service which will handle the fire in its incipiency and probably save a large expenditure of energy by the fire department, at a great saving of water, I fail to see where they should be charged for carrying it on.

As a little personal illustration: Just at the present time a concern in which I am interested is spending several thousand dollars in the installation of a sprinkler service for which we pay the installation expense from the main throughout the factory, but pay nothing thereafter for the sprinkler service. The saving would just about balance. The payment of the cost of installation would just about be met by the saving of insurance. But we look at it that if a fire is put out when it starts it is of less damage to us than if allowed to go on to a greater extent and be of some trouble to the municipality. I think we would be willing to pay quite a little insurance to be insured we would not burn rather than to be insured we would get good results when we do burn.

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*Derry, N. H.

MR. BURNHAM. I did not intend to convey the meaning which Mr. Bristol apparently gathered that payment for water pressure service has nothing to do with fire protection. What I did try to bring out is that if a factory owner enjoys a lower insurance rate because he has excellent fire protection from sprinklers supplied with public water than a neighbor with no sprinklers and therefore less fire protection, the Water Company or the community cannot properly claim any of the saving he enjoys from that difference in rates. There is no such thing as free water service for fire or any other use. Any kind of service costs somebody something, but I do believe that fire service charges can be fairly based on the cost of the service, as has been recommended by Public Utility Commissions and Water Works Engineers and Associations. Mr. Bristol has drawn an excellent parallel in his question. The Factory Mutual Insurance Companies do furnish insurance at cost, and it has been shown in many places that water companies or public Water Departments can supply fire service on the same basis.

To clear up the apparent misunderstanding of my reference to the recognition of private fire service as a beneficial one, I might say my meaning is that the service is beneficial to the community and not to the sprinkler user alone. With this benefit recognized, it follows that the Water Department or water company should expect to be paid for fire service by both the community and the sprinkler owner in their proper proportions in so far as it costs the water company anything to furnish the fire service, and in this I fully agree.

A "SUCTION BOOSTER" FOR CENTRIFUGAL PUMPS.

BY FRANK S. BROADHURST.*

This paper was not presented at a meeting. Members are invited to submit written discussions to the editor.)

An interesting arrangement has been installed by the author's firm to enable centrifugal pumps to be installed to operate with suction lifts materially higher than has heretofore been permissible.

Generally accepted good practice calls for a total lift not exceeding 16 ft. to the center of the pump impeller, this including the static lift from the lowest water level in the suction well to the center of the pump, and the friction through the suction piping and valves, together with the velocity head (generally a negligible item). In some cases 18 ft. and even 20 ft. are successfully attained as a total dynamic suction lift, but under such conditions the pump is usually difficult to prime and start, and frequently unstable in operation. The efficient satisfactory operation of a centrifugal pump depends upon the water entering the eye of the impeller as fast as it is discharged from the impeller, thus avoiding so-called "cavitation" troubles with consequent loss of efficiency and capacity, vibration of the pump and piping, erosion of the impeller, and liability of "dropping" the water. The rate of entry of the water can readily be figured, as this is directly proportional to the difference between the atmospheric pressure and the vacuum measured at the pump suction, and this difference is the absolute pressure causing the flow into the impeller. For example, with a 30-in. barometer and 18 in. of vacuum at the pump suction, there is 30 in. minus 18 in. or 12 in. of mercury absolute pressure available to keep the impeller filled. The actual weight of the water is acting against and away from the pump, and must be all overcome by the atmosphere if the pump is to operate successfully.

By the system shown in the illustration a centrifugal pump can raise water 25 ft. or 26 ft. with a barometer of 30 in. by so changing the arrangement from the usual one that a part of the weight of the water is utilized to keep the impeller filled at all times.

Instead of the suction pipe being carried directly to the pump suction, it connects to a sweep tee located about 3 ft. or 4 ft. above the suction opening. To the top of this tee is connected a small standpipe, the top of which is carried to a point at least 34 ft. above the highest water level in the suction well. The bottom of the tee is connected to the pump, preferably with a long radius elbow. To the top of the standpipe is connected a water jet eductor capable of producing a high vacuum, 28 in. of mercury

* Starkweather & Broadhurst, Inc., Boston, Mass.

or better. Such eductors are obtainable, and will operate with any water pressure from 30 lbs. per sq. in. or greater, and require only a relatively small quantity of water. Referring again to the illustration, as soon as the valve in the small eductor line is opened, the water pressure in the reservoir starts the eductor working, and rapidly exhausts the air from the pump suction piping and standpipe and fills the entire system with water. The pump

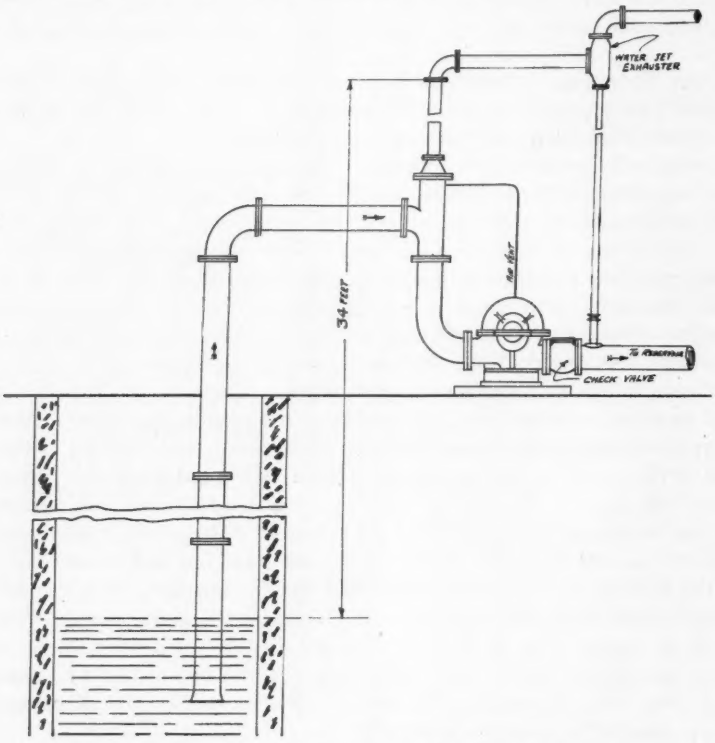

FIG. 1.—A "SUCTION BOOSTER" FOR CENTRIFUGAL PUMPS.

can then be started, and even with a vacuum as high as 24 in. of mercury in the suction branch of the pump case, it will operate quietly, giving full capacity, and as far as present tests show with practically the same efficiency as would be secured under a normal suction lift of 12 in. to 14 in. of mercury. The reason for this is:

1. The high vacuum maintained in the standpipe by the water eductor gives a sufficient differential or absolute pressure to cause the requisite flow to keep the pump supplied.

2. The vertical head of water of 3 ft. to 4 ft. from the inlet of the tee to the center of the impeller is acting downwards and keeping the eye of

the impeller (and consequently the impeller itself) filled at all times, and eliminates " cavitation " and its resulting evils.

It should be noted that the water jet exhauster can be replaced by a steam exhauster or a vacuum pump (steam, electric or belt driven), or where the main pumping unit is driven by a condensing engine or turbine, the standpipe can be connected to the main condenser and no separate vacuum-producing device is necessary, providing this condenser is capable of producing a reasonably high vacuum.

Another point to note is that after the initial exhausting of the system, very little air passes over from the top of the standpipe, only some incidental air leakage, and therefore the exhauster can be quite small. This is not intended in any way as a deaërating device, and the standpipe is purposely made small in cross section to avoid releasing considerable volumes of dissolved air from the water, to be handled and removed by the vacuum producer.

This arrangement is in successful daily operation with a 10-in. Morris Machine Works single-stage, centrifugal pump, delivering 2 304 000 gal. per 24 hours against 75 ft. dynamic head, with an average vacuum at the pump suction of 23 in. of mercury. It is probable that this same device could be used to advantage on reciprocating pumps which are frequently troublesome under high suction lift, although it has not been tried out for this service.

There are unquestionably many water works in New England where the plane of the water supply has gradually lowered with increasing demand, that may find in this system a solution of their pumping problems.

It is also believed that where the supply is obtained from a number of driven wells, with the customary sand chamber, by placing a centrifugal pump or pumps several feet below the sand chamber, and carrying a standpipe from the top of the sand chamber to a high vacuum pump or exhauster, these wells can be successfully pumped with a centrifugal pump, whereas, generally speaking, a centrifugal pump is not at present considered a highly desirable unit for direct connection to a multiple-driven well system, where the water plane necessitates a considerable suction lift, particularly during the dry season.

RANDOM NOTES ON SANITATION IN NEW HAMPSHIRE.

BY CHARLES L. POOL.*

[*Read February 12, 1924.*]

I am told that a certain New England Water Works man was visiting Scotland, and arriving at a village began to quizz the innkeeper on the subject nearest his heart: "What do you do to make your water supply safe?" "We boil it." "Is that all?" "No, we filter it." Probably thinking this to be only doing things by half he was further prompted to ask, "What other safeguards do you take?" "We drink beer."

This reminds one of the situation pertaining to a large number of the smaller public water supplies in New Hampshire, because it is so apposite. They neither boil it, filter it, nor resort to the expedient of leaving it alone altogether, in favor of beer. The supplies particularly referred to are those of towns of one or two thousands of population, wherein the supply consists of an impounded mountain stream, or a natural body of surface water from which a pipe runs downhill to the village. Individually they do not present a problem of very great concern, but collectively they do.

Sportsmen, woodmen, and tourists are more or less frequent on these watersheds which otherwise, for the most part, are such as to yield as clean and safe water as could be asked for. The problem is how to do away with the ever-present risk from infection of these supplies by marauders.

Treatment as a safeguard would be desirable, but none of the methods available fit most of these cases well, they being usually gravity supplies with their intakes remote from town. Mechanical filtration or chlorination would be so ineffectively controlled as to be practically worthless, and storage or slow sand filtration is beyond the pocketbooks of these towns, at least for the expenditure for these purposes, since the public health insurance premium would be so high that the money should rightfully be used for other purposes, perhaps in some other branch of health improvement; for instance, for helping support a district nurse to save babies, or perhaps for education.

In a few of these cases we have something definite to offer them, as when conditions are such that chlorine can be forced into the main, just before it enters the village, at a point accessible for care by some responsible individual. Then again a slow sand filter with a filtered water distributing reservoir, put in just below the intake so as to still have sufficient pressure left in town, would solve some cases; or the filter placed above the present dam with provision for diverting the excess flow to a point below the reservoir, when a stream is impounded. But there is little hope of securing

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these installations except where there are unfavorable conditions on the watershed too extensive to remove, or where the danger from visitors is unusually acute and cannot be lessened.

In protecting these watersheds from this chance contamination by visitors something can be accomplished, but the results obtained are far from complete. To hire a patrol officer, who would be an asset for each of these, is impracticable, but some control of the watershed is accomplished in most cases by getting hold of the right individual in the community and persuading him to give part of his time to occasional visits to the more important parts of the watershed. Warning signs are put up and undoubtedly help, particularly with the better element. Often the people who frequent the watershed can be seen, and their good will in avoiding carelessness be secured.

I chanced on an example of this last summer at an inspection of a girls' camp in the mountains, when I learned that one of their regular routes for hikes lay over a trail up Hurricane Mountain and past one of the brook reservoirs supplying North Conway. A party on their last trip had come to the reservoir tired and dusty, and some one having previously acted on the assumption that the posters were a mistake, the girls did not know what the little reservoir was for, unless perchance it had been placed there for them to wash their feet in. The senior girl in charge would not allow it, happily, but I got no details of their peregrinations on other parts of the watershed. The camp director was only too pleased to have, in the future, for one of the camp rules, the desired conduct on the watershed.

The policy of gradual purchase of available parts of the watershed by the water interests is urged, and they are coming to own more and more of this land, although this is progressing rather slowly for the small supplies we are here considering. Reforestation and destruction of trails and mountain roads is also urged. Often a path or useless road leading up beyond the intake can be planted with underbrush and the visitation of the watershed made so unattractive that it will be infrequently visited. For these improvements, ownership is a prerequisite.

If we so desired, we might get around the quandary we are in with these small gravity supplies by requiring them to treat their water, or adopt rules for the protection of the watersheds, which would look fine on paper but be costly in the end, and then say, "Look at the wonders we have accomplished!"—illustrating it with a diagram showing marvelous increases in installations, etc., by having a line start at the lower left-hand corner of the picture and zigzag like a lightning flash to the upper right-hand corner; but we are proceeding with the hope that slower and surer methods will better benefit everybody concerned.

A brief history of some of the troubles of the town of Littleton with its water supply has some points bearing on some of the watershed control problems noted above. In the winter of 1902–3 Littleton had a typhoid

epidemic of 139 cases and 11 deaths, caused by using polluted river water, which is the only water-borne typhoid epidemic New Hampshire has had for many years. They immediately procured a new supply by impounding a mountain stream eleven miles away. In 1915 the stream was endangered by lumber camps operating on its banks. Attorneys for the lumber company and the Attorney-General representing the State Board of Health held conferences, and an agreement with the Littleton Water Commissioners was reached whereby the lumber company removed its camps to another valley beyond danger. Regulations for this supply were immediately adopted by the State Board of Health, which included the requirement that future camps should not be erected without approval of the Local and State Boards of Health. On December 9, 1919, it became necessary that a superior court give orders to another lumber company to carry out still further detailed regulations concerning sanitary precautions to be observed on the watershed. A second order was necessary January 15, 1920, requiring fulfillment of parts of the first injunction violated, and a third necessary on February 4 when the company was ordered to vacate the site by February 13, in connection with condemnation proceedings instituted by the town. The tract was bought at a cost of over $60 000 to the town of 4 000 persons, and other lots at high cost are being bargained for. A few years ago these could have been bought for a song. The town in buying these tracts considered the value of the trees for conserving water, as well as protection of its purity.

A recent example illustrating the importance of protecting these supplies from accidental contamination was furnished, not by one of these supplies, but by a larger one where most of the considerations making for difficulty in securing proper protection are by no means of the same weight as for the little supplies.

An epidemic of 1 000 cases or more of bowel trouble occurred in Keene, a city of 11 000 in the southwestern part of the State, in October, 1923.

An exceptionally dry period was slightly interrupted by a rainfall of $\frac{1}{8}$ in. on October 14. The epidemic began October 16 and lasted for only a few days.

The cases were described as gastroenteritis and were characterized by sudden onset, abdominal pains or stomach burns, nausea with usually vomiting of bile, followed by diarrhea lasting 12 to 24 hours, and sometimes longer. There were no fatalities, and the cases were usually mild except among elderly persons.

The milk supplies were eliminated, and no other agency could be found which could be reasonably suspected except the water supply. There were numerous reports that there was widespread prevalence of the disorder in neighboring towns and in Massachusetts, and local opinion was divided as to whether climatic conditions or the water was responsible.

Massachusetts authorities contradicted the reports of epidemics in that State, and visits to neighboring towns disclosed but relatively few characteristic cases, all of which had visited Keene shortly before their indisposition.

The Keene water supply is from a woodland stream subjected to no storage or treatment. There are few habitations on the watershed and from these no established pollution is considered likely, especially in dry times, as at the time of the epidemic.

There was considerable visitation on the watershed, however, by men hauling lumber, and hunters or fishermen. The two existing cross connections holding out unsafe water were found to be tight.

For several months previous to and including September 4 the periodic analyses by the State Laboratory had indicated unusual freedom from *B. coli*, an analysis made elsewhere October 8 was reported satisfactory, October 16 the epidemic, October 18 substantial fecal contamination (*B. coli* of the fecal type present in 1 c.c.) in four tap samples was found, persisting October 20. October 22 analyses indicated a clearing situation with some residual contamination in the mains, and October 29 and subsequent analyses were bacterially satisfactory.

The Division of Water Supplies of the State Board of Health judged the epidemic to have been water-borne, and probably due to contamination at the source by some visitor. Stringent attempt to induce the city government to chlorinate the supply followed. The matter is still pending. For $9\frac{1}{3}$ years ending December 31, 1923, *B. coli* has been found to be present in 10 c.c. portions 45% of the time, and in 1 c.c. portions 20% of the time. These results are believed due to incidental pollution, as opposed to a constant feeding from some established source of contamination on the watershed. The supply is unsafe.

Thus far the principal reference has been to supplies of one certain kind only, and the same problem must exist in other States with a considerable rural population, and may give a gloomy picture, but it is not a representative picture of the whole water-supply situation in New Hampshire. Generally speaking, the supplies are of good quality, derived from clean watersheds, and well taken care of.

The time of most rapid increase in the number of supplies installed and in major improvements of existing supplies is passed, and the present problem is more in the nature of maintenance and gradual improvement than constructive.

Chlorination is only used as a safeguard to supplies already tolerably safe, and sole dependence is not placed on this agency for treating polluted waters. We are working to secure the maximum efficiency of operation of these machines, and urge duplication of installations and parts. In three plants already the installation is in duplicate, giving a reserve in case of breakdown, and in one other a complete outfit for treating with hypo-

chlorite is ready in case of a breakdown of the liquid chlorine machine. Polluted river waters are used for only two or three supplies, and these are treated; and even these raw waters are not badly polluted. Operators of chlorinators have recently been supplied with outfits by the State Laboratory and have been instructed in the control of dosage by means of the ortho-tolidin test. The procedure consists in adding 10 drops of the test solution to a bottle of the chlorinated water, and adjusting the rate until the color comes between the colors in two other sealed bottles of the same size. The efficiency of chlorination has been found to be greatly increased by the use of this method. It was adopted from the method used by the Virginia State Board of Health, which is described in full in the September, 1922, issue of the *American Water Works Association Journal.*

Chemical, as well as bacteriological, examinations are periodically made, not only for the public water supplies, but also for semipublic and private supplies. These latter are considered to have done and to be doing a large amount of good. Not only from the direct advice which follows each analysis, but from the interest in improving these supplies which is thus stirred up, is betterment expected. The examinations of public supplies are indispensable, since except for a few supplies, periodic analyses are not made elsewhere.

More work than in most States has been done on lead and zinc determinations, and articles on these metals concerning their relationship to water consumed have been written recently by C. D. Howard, Chief of Division of Water Supplies, Foods and Drugs, and published in the March, 1923, issue of the *American Journal of Public Health,* and the May, 1923, issue of the *American Water Works Association Journal* on lead and zinc, respectively. Where lead pipe is in use, the resulting amount of lead in the water is determined, and the following table from the former article shows the decrease in proportions of samples examined having lead in distinctly dangerous amounts, consequent upon wholesale abandonment of lead pipe:

Period	Total Lead Examinations.	Per cent showing 0.500 p.p.m. or more.
1909–10	699	49.5
1911–12	677	39.0
1913–14	632	45.0
1915–16	581	33.2
1917–18	371	24.0
1919–20	439	21.4
1921–22	380	18.7

Sanitary inspections of public water supplies have been made for many years, and the amount of work in this line was increased three years ago. Sanitary control of water supplies is considered to be of first importance in work in environmental sanitation in New Hampshire.

One of the major activities in sanitation in recent years has been the improvement of drainage conditions about the shores of the larger lakes, Winnepesaukee, Squam, Newfound and Sunapee Lakes receiving particular attention. It is planned to extend the work to the smaller lakes and ponds, some having been done already. These lakes are virtually reservoirs for drinking water, public supplies being derived from three, and semipublic and private supplies from all four. They are also important summer resort lakes. The old state law in force for many years specified $\frac{1}{4}$ mile as the distance swimmers were to keep away from intakes, and the major part of control work on this problem was directed to the enforcement of its provisions. At the last legislature the distance was struck out with the limits henceforth to be at the discretion of the health officials.

Another major activity has been inspection of summer camps. Most work has been done on boys' and girls' camps, of which there are 170 in the State, giving recreation annually to 10 000 persons. Conditions have been found to be good at these camps, and this branch of the work is to be largely diverted to auto tourists' camps which are springing up everywhere. These all involve the inspections of water supplies — wells, springs, and surface sources.

Typhoid-fever mortality in New Hampshire has been declining with the increase and improvement of public water supplies, comparing favorably in this respect with the other New England States and very favorably with the northern ones. The highest death rates are not in the smaller towns without public water supplies, nor in the largest cities, but are to be found in the mill towns. No relation is traceable between the characters of the water supplies in different towns and the typhoid death rates of these towns, and the public water supplies are considered to have had no connection with typhoid-fever cases in recent years.

In the small towns the water supplies vary in respect to the amount of cattle pollution they receive, and effects are traceable in varying degrees in tap samples. The work of securing entire freedom from this objection is in progress. The writer has been interested to compare the effects on inhabitants and visitors, of the varying degree of this pollution, by questioning local physicians as to the extent of bowel troubles, but thus far has been unable to find any increased ill effects from the waters inferior in this respect. This is not offered as evidence that such pollution is harmless; the data are too inaccurate.

This paper is not intended as a survey of the field, nor more than its title suggests.

Discussion.

Mr. A. L. Gammage.* I would like to ask what part per million excess chlorine is used in treating the supplies?

Mr. Pool. Between 0.10 and 0.20 parts per million. This quantity, in the cases where we have enough bacterial results to check up, has been sufficient for the clear New Hampshire waters we have had to deal with.

Mr. M. N. Baker.† I would like to ask Mr. Pool whether all the water supplies of the State are examined for lead, or whether it is only those where you think there is some danger of lead poisoning. That would make quite a difference.

Mr. Pool. Yes, that correction does enter into the figures that I mentioned. The practice is to send out, with all containers in which samples for chemical analyses are to be returned, a questionnaire, and on that they are supposed to specify whether lead pipe is in use or not, and it is only in cases where lead pipe is used that the analyses are made.

E. S. Chase‡ (*by letter*). Mr. Pool's paper brings out clearly the difficulties encountered in securing proper sanitary protection of small public water supplies. Practicable and inexpensive measures for making such supplies safe are often difficult to establish. Where treatment is advisable and where adequate supervision of operation is liable to be lacking, slow sand filter plants appear to promise the greatest degree of safety with the minimum of supervision in the case of our relatively clear New England waters. In the case of larger supplies, rapid sand filters and chlorination are measures which may be adopted. Each water supply is an individual problem.

Rules and regulations for the sanitary protection of watersheds may help somewhat, particularly as regards the more flagrant acts of pollution, but several years' experience with the actual enforcement of such rules and regulations make the writer feel somewhat skeptical as to their real efficacy. In New York State the procedure laid down by law for the enforcement of rules and regulations enacted by the State Department of Health for the protection of watersheds is cumbersome and slow of operation.

Mr. Pool refers to the experience at Littleton and the purchase by the town of watershed lands at the cost of $60 000. The question arises as to whether, for a town of the size of Littleton, it would not have been better for that amount of money to have been expended for a filter plant.

The epidemic of gastroenteritis in Keene in October, 1923, appears very similar to an outbreak during the fall of 1914 in the village of Hudson Falls, N. Y., which was studied at that time by the writer. A description of the water supply of Hudson Falls, together with an account of the circumstances surrounding the outbreak of enteritis there, will be found in

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‡ Sanitary Engineer, Metcalf & Eddy, Boston, Mass.

the 1914 annual report of the New York State Department of Health, Vol. 2, page 355.

Mr. Pool's statement that the typhoid death rates in New Hampshire are highest in the mill towns suggests the possibility of polluted industrial supplies being readily accessible for drinking purposes by mill workers and also the possibility of the contamination of the public supplies by such industrial supplies through cross connections.

MR. POOL (*by letter*). Mr. Chase's last observation is pertinent and if this *has been* a material factor, a few years more of typhoid figures will show a change, because since 1919, enforcement of provisions of a law of that year is practically complete, wherein industrial supplies are separated from the public supplies by accessible double check valves, and drinking water for the mill operatives is taken from the town mains.

TOPICAL DISCUSSION.

CONTROL OF STREET OPENINGS.

[*March 11, 1924.*]

MR. HENRY A. VARNEY* (*by letter*). One of the most difficult problems confronting the officials responsible for the maintenance of road surfaces in every growing city or town, is the proper regulation of street openings or excavations made for the purpose of laying pipes, conduits, etc.

It is seldom that the underground work is completed in a street before the surface is laid, even so far as the mains are concerned, and it is, of course, impossible to provide for all house services in advance. When it is realized that, even in a residential street, there are, or should be, at least six separate underground structures running the entire length of the street, with connections from every structure to every house, something of the difficulty of maintaining a road surface may be appreciated.

In some municipalities, where the sewer, drain, and water connections are all laid by the city or town, and are under the control of the same department head, these services are laid in the same trench. This should be done, however, only when the sewer is very little deeper than the water pipe, on account of the liability of damage to the latter from unequal settlement.

If the sewer and drain connections are not laid by the city, it is very difficult to plan the work so as not to keep the trench open and the street blocked for an indefinite period. Then again, the mains are often on the opposite side of the street from the building which is to be connected; and this complicates matters greatly.

When connections are installed by public service corporations, so called, as for instance, gas, electric light, or telephone companies, it is, of course, impracticable to lay them all in the same trench. So under the best conditions, there must be at least four separate trenches for each residence or business building. This means that a large proportion of the total area of a road surface must be destroyed and rebuilt.

Before the permanent surface is restored, it must be certain that the foundation has been replaced in such a manner as to prevent any future settlement. In certain soils, such as sand and gravel and like nature, this is a comparatively simple matter, except where sheeting has been used to support the banks. In such situations, unless the sheeting is withdrawn at the time of backfilling, there will probably be cavities behind the sheeting which cannot be filled by ramming and will be very difficult to fill by puddling.

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* Town Engineer, Brookline, Mass.

There have been cases in Brookline, where settlements have occurred ten years after the structures were completed and which have continued for many years after they first began to appear at the surface.

Where the soil is clay or hard pan it is practically impossible to restore the backfilling so that no subsequent settlement will occur, and in such locations, if not in a main thoroughfare on heavily traveled streets, it is better not to attempt to replace the permanent surface at once, but use temporary methods of maintenance until the following spring. When it is fairly certain that there will be no more settlement, the reconstruction should be completed, using, of course, the same kind of material as in the adjacent roadway. If, however, the excavation is in a business section, or in a much-traveled thoroughfare, the permanent surface should be laid as soon as the backfilling is completed. This can be done by covering the trench with a concrete slab of sufficient thickness to carry the traffic, care being taken to extend the concrete a sufficient distance beyond the sides of the trench to provide a proper bearing in case the backfilling should settle.

In streets where the original pavement was laid on a concrete base, the permanent surfacing should be relaid at once. The old concrete base should be removed to such a width as to give a bearing to the new concrete on solid ground on both sides of the trench, as above described, and the pavement itself to a slightly greater width. The thickness of the new concrete base should be somewhat greater than that of the original, depending on the width of the trench, to enable it to carry traffic without the support of the backfilling.

In streets having bituminous macadam surfaces, the trench should be carefully filled to within three inches of the surface, then brought nearly to grade with No. 1 stone. This stone should be bound with a small amount of cold patch material and the whole surface thoroughly rammed or rolled. After rolling, the surface should be little, if any, higher than the adjoining surface; that is, no attempt should be made to anticipate settlement. This should be taken care of by adding patching material, when required, or, if the settlement is considerable, by more broken stone bound with "cold patch." If the backfilling has been replaced in a proper manner, there will be about enough settlement to provide a depth of road material sufficient for the average bituminous road. The method usually followed, of heaping up material on the trench to allow for settlement, should not be allowed, as this creates a very dangerous condition for all classes of traffic and, furthermore, a portion of this top should be finally removed to allow a proper surface to be relaid, as the original road material is seldom saved and replaced on top.

The patching material, above referred to, may be made of pea stone ($\frac{1}{2}$-in. stone) mixed with Barrett Company K. P. or Headley's No. 1 patch, or some similar compound in the proportions of one cubic foot of stone to one gallon of K. P.

All work connected with the replacing of the road surface should be carried out by the street department of the city or town.

Before a permit is issued to excavate in any street, for any purpose, the size of the proposed opening should be ascertained and the applicant required to make a deposit sufficient to cover the cost of restoring the surface to the original condition, and all incidental expenses.

Connections with structures owned or controlled by the city should be made by the city, the actual cost being paid by the owner of the property. The method often followed, of allowing such work to be laid by private parties, even under the license system, is most unsatisfactory, as it is difficult and expensive to properly inspect and locate the connection, and the cost to the owner is often excessive; and the restoration of the road surface can be more economically and satisfactorily completed when all the work is carried out by the municipality.

THE PRESIDENT. This is a subject we are all very much interested in. I would like to ask if there is any city or town represented here in which the water department allows any other utility, such as gas pipes or sewers, in the same trench?

MR. RICHARD H. ELLIS.* It has been the custom in North Andover to install both the water pipe and sewer in one trench. That is probably due to the fact that these departments are under one head and it saves cutting the road in approximately the same location to make installations.

THE PRESIDENT. I would like to ask Mr. Ellis relative to the depth of the sewer. If the water pipe is at a greater depth in the trench than in the sewer, what do you do?

MR. ELLIS. In that case they are not laid in the same ditch. Only if the sewer is deeper than the water pipe.

MR. HENRY T. GIDLEY.† In Fairhaven we do not like to have the water service laid in a trench with any sewer or any other pipe, but in some cases we have done that, especially where it is all ledge. And in that case, where the sewer is at a greater depth, we carry the water pipe along the side of the trench. We have done it in a few cases but we do not like to do it as a rule.

MR. FRED L. CUSHING.‡ In the city of Medford we have a Water and Sewer Department which lays the sewer connection and the water connection in the same trench, almost universally. They are responsible for both connections and they maintain them.

THE PRESIDENT. I can see that where the sewer and water departments are under one head it can be done all right; where there are different heads it is all wrong.

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* Superintendent, Board of Public Works, North Andover, Mass.

† Superintendent, Fairhaven Water Co., Fairhaven, Mass.

‡ Water Registrar, Medford, Mass.

MR. HENRY V. MACKSEY.* The matter of taking care of street openings is one thing from the Water Department's point of view but quite another thing from the point of view of the Street Department, and those of us who happen to handle both departments get both points of view.

I can remember, many years ago, when I was in the Street Department in Boston, I found a great deal of fault with the way trenches were taken care of by the Water Department, though they were under a very able engineer, — Mr. McInnes. At the same time I found much more fault with the way such work was done in the Sewer Department under Mr. Dorr. Now that I have all their responsibilities, I take a more charitable view of this work.

I believe that all the work that falls to the municipality, that is connected up with either our water service or our sewer service, should be done by the municipality itself. It should do all the work and bear all the responsibility. I do not believe that it is good policy to put the two services close together. I believe they ought to be in separate trenches. Sometimes we have to give way to the opinions of others. We know that we would not, except under very unusual conditions, locate both the water and the sewer mains in the same trench. No matter what we may do, the trench will give some trouble, and the best method of handling the maintenance and final repair is to give the Street Department sufficient authority to do the work, and to charge the cost of same to the proper department. In the case of a gas company, or other private organization, a deposit should be made in advance so that money will be available to pay for the work. In the case of other departments of the municipality itself, there is a great deal of difficulty, due to the short-sighted policy of some water and sewer departments which try to make street repairs as cheaply as they can. I do not think it is necessary, if the trench is properly backfilled, to put any stronger concrete over it than it had before excavation, but we should cut back on top so that our patch extends well beyond the sides of the trench, giving it support on the shoulders as well as on the trench itself.

In regard to the length of time that a trench can stand without settling, I have no data that are convincing, but I have one case before me now where a street settled down for a distance of about seventy-five feet in length, and running from nothing to fifteen inches in depth in the middle, over a sewer trench which was backfilled in 1897, and there has never been any serious settlement until this spring. A macadam top had been put over it and yet this winter it has gone down fifteen inches.

THE PRESIDENT. I would like to ask Mr. Macksey a question. I have met several superintendents of streets who object to using water for backfilling. What do you say to that?

MR. MACKSEY. There are certain materials, such as sand and gravel, where the best thing we can do is to settle them right down with water.

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* Superintendent, Public Works, Framingham, Mass.

THE PRESIDENT. They object to using water.

MR. MACKSEY. I certainly would not object to it on sandy material, and I do not think you would; would you?

THE PRESIDENT. No. I have tried to argue the other way, but two superintendents insisted.

MR. MACKSEY. Anyone that tries to tap sand once will not try it the second time.

MR. JOSEPH A. HOY.* In Worcester the practice is for us to make a requisition on the Street Department for a permit before we open up the street, and within twenty-four hours after the work is completed the permit is returned to the Street Department and it is up to them to take care of it and charge it to the Water Department of the city.

* Foreman, Water Department, Worcester, Mass.

TOPICAL DISCUSSION.

Why the Applicant Should Pay the Actual Cost of Service Installation From Street Main to Meter.

[Read February 12, 1924.]

President Heffernan. The next number on the program is a topical discussion on "Why the Applicant Should Pay the Actual Cost of Service Installation from Street Main to Meter."

I will call on Mr. Bristol of Ansonia to start the discussion.

Mr. Theodore L. Bristol.* Mr. President and Gentlemen: Mr. Heffernan wrote me that he might call upon me on this subject, and I thought that I would prepare myself after I got here by consulting the library; but I find there is nothing in the library about it, so that I had to think up a few points on this subject.

This is a very opportune time to bring up this matter as far as the privately owned water companies in Connecticut are concerned, because a few days ago we were summoned to appear on next Friday before the Public Utilities Commission to confer with them about the advisability of their establishing a rule in reference to laying service pipes, and the maintenance of the same, from the company's main in the highway to the curb or property line of the consumer.

We have a Connecticut Water Works Association, and we did not really know what this meant and what brought the subject up, but it is a question of policy, if we understand it, with the Commission, as to what they shall do when they have cases come before them in reference to the laying of service pipes. The procedure in different cities in Connecticut is different, and at a meeting that was held by the privately owned water companies we decided that we would ask the Commission not to make any rule but to allow whatever action was taken in each town to go on, because the procedure is so varied.

In the first place, one reason that I can think of as to why the consumer should pay for the service is that the general distribution system of the water works is in the main pipes. The service pipes, to serve the individuals, will vary in cost according to the individual requirements, and those requirements vary according to the size of the service pipe, the length, the character of the digging, and various other conditions which may increase or decrease the cost of installation. It therefore seems that to put the burden of the cost of installation of service pipes on the individual is fair and equitable. If the water works makes a flat charge, or furnishes the service free, the cost is discriminatory and unjust, as the consumer with a

* President, The Ansonia Water Co., Ansonia, Conn.

low-cost service in the long run pays for the high-cost service, or the extra cost of it, and the burden is not placed where it belongs.

It seems to me it is considerably like putting items in the general expense column which can be with justice allocated to individual accounts. If the consumer has to pay for the service pipe, it is also true that he will not ask to have the service pipe relaid so often. He will not have so much trouble or so much complaint if the remedy is at his expense. We find it, in our own company, quite satisfactory to us. We lay the service pipe at cost plus 10 per cent, without any overhead and without adding anything for compensation insurance and profit. We practically lose money, but our own men do the work and are used to it. We know what we are putting in — where it is, and we put in the best pipe and fittings. As a matter of policy, we think it is better for the consumer. We know it costs him a great deal less because we do not use Union labor.

Mr. George A. Carpenter.* The practice in Pawtucket is for the municipality to lay the service at its expense from the street main to the property line. After that, the individual has the privilege of laying the pipe at his expense from the property line to the inside of the cellar wall where the meter is installed. Recently all our people who are in active touch with the situation have reached the opinion that it would be a much better policy for the municipality to lay the whole of the service from the main into the house, to where the meter is installed, because there always arises the question when the work is done by different parties, of who is responsible or to blame when there is some stoppage in the flow. Then, again, sufficient care is not always used by the plumbers who do the work between the property line and the cellar wall as to how they handle that portion of the service line.

Mr. F. F. Forbes.† The town of Brookline always has laid the service pipe from the main to the property line, and in nearly every case we lay the pipe to the house, and we charge what it costs us to lay the pipe from the street line to the building. That has been our practice for forty-nine years. We have very little complaint, — very little indeed.

Mr. Hugh McLean.‡ Do you charge for running from the main to the property line?

Mr. Forbes. We do not, although perhaps we should. Everything in the street the town pays for.

Mr. Hugh McLean. Holyoke's policy is about the same as has been stated. We lay the pipe from the main to the meter, or to inside the cellar and we charge the whole bill. We have had some trouble lately in doing that, in being able to collect the bills as promptly as we should, so that at the last meeting we held, our rules were amended so as to exact from each petitioner a deposit of $50 for new services; in that way guaranteeing us payment of the expense that we are put to by running the pipe from the

* City Engineer, Pawtucket, R. I.
† Superintendent, Water Works, Brookline, Mass.
‡ Water Commissioner, Holyoke, Mass.

main into the cellar. If it does not amount to that much we give the balance back to them. Previous to that, we acted on the petition, put a service in, mailed them the bill, and gave them 10 per cent off if paid within thirty days. Many people did not take advantage of that discount, so that at the last meeting we ordered all bills collected, and started the new rule so that we would not be bothered with that any longer.

Our experience is that it is better to control the pipe to the inside of the premises.

Up until seven or eight years ago we only carried the pipe to the curb, and our experience was that the service pipes between the curb and the cellar froze on account of their shallow depth, and the person connecting at the curb would sometimes have an elbow go down to it. When we tried to clean out such pipes it was impossible to do so. It is a great deal better, in my opinion, for the user of the water and for the Water Department to have the latter do the work from the main to the inside of the premises, and I think that the property owner should be charged for it.

MR. JOHN F. SULLIVAN.* We are practically in the same situation as our neighbor, the city of Holyoke. During the last eight years we have made it a rule to require a deposit from the consumer or contractor. This deposit is $50 on the state highway or $40 on city streets. We have a sandy soil in our city, enabling us to drive most of our connections. The required deposit gives them the connection direct from the main to the cellar. In past years connections were made to the curb only, the balance of the work being done by the plumber who would in turn disturb the curb stop, thus causing a leak in a short time. This would necessitate the Water Department going back and digging up the curb and repairing the leak. This deposit overcomes all such difficulties and in nearly all cases covers the entire cost of installation of connection. In the summer time we install a meter as soon as the connection is completed but, owing to freezing, we discontinue this after November. If the amount of the bill exceeds the deposit, a bill for the balance is mailed the consumer; if the bill does not amount to the deposit, the balance is returned with a receipted bill. Our connections are generally below $40, excepting on the State Highway.

PRESIDENT HEFFERNAN. It is quite interesting to hear Mr. Sullivan speak about pushing the pipe through sand. It would be interesting to the members, I am sure, to know how that is done.

MR. SULLIVAN. We do not use a pipe-pusher, we use a lead hammer which we make ourselves out of a short piece of 3-in. pipe filled with lead. One hole is dug at the curb, another at the main, and it requires one man to do the driving and one man to hold the pipe. We generally wait until the cellar is dug out, driving from there to main. We use a solid cap on the driving end of the pipe, a common plug screwed into a coupling on front end of the pipe. Of course there are certain parts of the city where hard pan is found, and if an application is made in these districts for a connection the men go from the shop prepared to excavate, and lay the pipe accordingly.

* Chicopee, Mass.

MR. MCLEAN. I will say that Holyoke does the same. Most of the services are driven. We dig down and start off with a short end, and drive it in and snake the pipe right through.

MR. STEPHEN H. TAYLOR.* Up to about a year ago New Bedford furnished the pipe to the street line for $2, charging the cost inside, which was most always done by the city, to the owner, — the actual cost. That works out all right if you are getting a rate high enough to make up for the difference between the $2 fee and the cost of the service. Our rate is not a great deal more than our cost of delivering water to the consumer. The result was that we were going behind in proportion to the number of services we put in. Last year about 700, and the year before nearly 750 services we furnished for $2, which cost from $25 to $30.

A year ago the Board adopted a policy of charging the entire cost of the service to the owner, but in view of the fact that our mains are located on the west or south sides of the street it did not seem fair that the property owners on the north and east sides should pay twice as much as those on the other two sides. So we figured the total cost of laying all services and reduced it to a cost per service of the various sizes. We use three sizes, — $\frac{5}{8}$-in., $\frac{3}{4}$-in., and 1-in. pipe. And we fixed a price for each size which would cover that average. That is, we practically assumed the main was in the middle of the street and the owner paid a fixed charge from the middle of the street to the property line. As we figured it last year the cost was $27.50 for $\frac{5}{8}$-in., $30 for $\frac{3}{4}$-in. and $35 for 1-in. This year we refigured the cost. Material, as you all know, is higher, and labor is about the same; $\frac{5}{8}$-in. services are now $31, $\frac{3}{4}$-in. $32, and 1-in. $39. We intend hereafter to charge the property owner the actual average cost per service of the size installed for his property.

As to collecting for that service, Brother McLean said he had trouble. We always collect the bill for installing the service before turning the water on, which I think is a good policy. Otherwise, it is apt to drag along for a long time.

In a street where there is a permanent pavement, which requires an extra expense, a recent vote of the Board was that the particular cost of that expense be charged to the owner. We do not distribute that over the total number of services, because most of our services are on streets which are not permanently paved; being in the outskirts of the city where there are only dirt streets. That seems to work out, I think, very well. As I say, if we had not done that we would have gone behind considerably financially.

It seems to me that the owner should pay the actual cost of the service as nearly as possible, as it is for his individual benefit, including, as I say, the street repair cost where such repairs are necessary.

MR. S. A. AGNEW.† We charge three dollars ($3.00) for tapping the main and it includes the corporation cock, lead connection, curb cock and

* Superintendent, Water Works, New Bedford, Mass.
† Superintendent, Hingham Water Co., Hingham, Mass.

box, and this connection extends to about two feet from the main. From that point the taker is charged for all labor and material at a little above actual cost.

We like to do the entire work to the cellar, as experience has shown that trouble often follows if the plumber does underground work. However, if the taker wishes to do the work inside his own line, we require this pipe to be installed before the street connection is made, and we make the connection to his pipe rather than he connect to ours. We require this because plumbers making connections to our pipes are apt to turn over the curb cock, or even loosen up the lead connection, necessitating the digging up of the street a second time.

Our curb cock, by the way, is not at the curb at all, but is connected right at the end of the lead connection and is located about two feet from the main. We do this for the reason that in case of trouble between the curb cock and the corporation cock, the digging of one hole gives access to both cocks.

The cost of street service work has always been a bone of contention. Many people raise a row when presented with a bill for service pipe in the street. They say, and with a certain amount of reason, "Why should I pay for that? That is out in the street; I have nothing to do with it; that belongs to the Water Company." Well, whether it belongs to the Water Company or not, they have to pay the bill, but on general principles I have often questioned the wisdom of the charge. I cannot tell my consumer that, by the way, but nevertheless I have often wondered to myself why they should pay for that service pipe which is in the street and over which they have no more control than over the mains. I suppose if my directors heard me say this, they would call it rank heresy; nevertheless, that is my private opinion.

After all is said and done, there is just one reason for this charge,— we cannot afford to do it for nothing with present rates. If it were possible to fix rates so they would cover this expense as a part of the construction cost of the work, there would be less irritation to the general public; but, unfortunately, like the five-cent car fare, people have a certain amount fixed in their minds as the reasonable amount they ought to pay for water, and a company undertaking to charge more immediately gets into trouble. The company's only source of revenue is from the sale of water, and this revenue must be enough to pay all its expenses and a little return for the people who invested their money to build the works; and, goodness knows, this return is not very large in most public works. The municipality is more fortunately situated; being actually owned by the water-takers, the department can very comfortably go to the town meeting and ask for an appropriation to make up any deficit. The company, finding itself short, can do but one thing, — cut the dividend.

It can readily be seen why a charge for service work is made — to keep down construction cost. If, for instance, a corporation installs a thousand

services at a cost of, say, $25,000, without direct charge to the taker, it must be charged to capital account and some return expected on the investment, — somebody has to pay for it, and this somebody is the ultimate consumer. Evidently, experience has shown that it is easier to make a direct charge for this work, collect the bill before the water is turned on, and have the agony over.

Therefore, as I say, we make an initial charge of three dollars ($3.00) for tapping the main, which includes the curb cock and box, and besides charge for all labor and material used beyond that point.

A MEMBER. Is it not more expensive and inconvenient to dig a hole out in the center of the street than it would be near the gutter, the edge of the sidewalk?

MR. AGNEW. Ours is a country town. The town scraper or scarifier, or the road roller, comes along, and the first thing it does is to squash down every service box. We cannot repair the curb cock unless we dig up the corporation cock and shut it off. Therefore, we have to dig a hole down in the street. If the curb cock is beside the corporation cock one hole will answer the purpose for both.

MR. TAYLOR. If you had that curb cock at the sidewalk, inside of the curb, would not you reduce the breakage a great deal by steam rollers and scarifiers?

MR. AGNEW. Mr. Taylor lives in New Bedford where they have well-defined curbs, whereas we live in a country town where there are very few well-defined street lines.

MR. ALLISTON F. HART.* We charge for our services from the sidewalk in, and we make a $5 tapping charge. We lose money on it, and we know it. The average service in Walpole costs us $30 or $35. There may be some that will run a little more, and some a little less, but that is the average. Now, we charge $5 as a tapping charge from the curb, and the Water Department pays the balance. The town pays, and we can afford to give that money back to the consumers from the fact that it is a new customer and eventually he will pay for it all. We charge the exact cost of installation from the curb in, and send them the bill afterwards, and do not turn the water on until we get the money. Our town is entirely metered. We use something around a million gallons a day.

MR. MCLEAN. Nothing has been said relative to the cost of renewals. Suppose a service has been put in from the main, has lasted twenty-five or thirty years, and needs to be renewed. We charge for that. When a service has become obsolete and useless, we put it in and charge the owner what it costs.

PRESIDENT HEFFERNAN. That is very important.

MR. JOSEPH A. HOY.† In Worcester, if the service is gone, or worn out, the owner is notified to make application for a change of service, and the practice is the same as where the original service was put in. Our men

* Town Engineer, Walpole, Mass.
† Foreman, Worcester, Mass., Water Department.

in Worcester make the tap at the main and run the service pipe from the corporation cock at the main to the stop and waste at the cellar, installing the meter at the same time.

The practice in Worcester for a good many years, probably for about ten years, has been practically the same as Mr. McLean states. The owner is obliged to make a deposit to cover the cost of the service.

Now, on the digging and the trenching, when you have a good macadam or granite-paved street, the city is obliged to stand the expense of the excavating and resurfacing and the repaving of the street. In justice to the city, I do not think that is right. From the street line to the house the owner is obliged to pay for it.

In the cleaning of that service afterwards, in ten, fifteen or twenty years, whenever required, the city cleans it at its expense unless the pipe happens to break in the process of cleaning. If the service is in bad-looking condition in the cellar, we so inform the owner, telling him it probably will be necessary to put a new piece of pipe in at his expense, and then we start and clean out the pipe. The practice which has been in vogue for a good many years is that the owner is required to put down a deposit to cover the installation of the service from the street line in to the meter, — all on the owner's premises.

MR. AGNEW. The city puts in the service pipe from the main to the property line at its expense?

MR. HOY. At the city's expense to the property line and at the owner's expense from the street line into the cellar.

MR. GEORGE A. KING.* The city of Taunton runs the service pipe from the main to the cellar and charges the owner for that part which is on the owner's land, the city paying the cost of the street work. We make out a bill and the owner has to pay it before he can have the water turned on. We allow no one to lay underground pipe more than a foot deep unless it is metered.

MR. A. R. HATHAWAY.† It seems to me that, in this discussion, we have wandered somewhat from the main subject as printed on the program card, which subject is there given as pertaining to the payment by the consumer of the cost of installing his service from the street main to the meter.

The subject logically divides into two parts: who shall do the work of installing the service and then who shall bear the cost of same.

In regard to the work of installing the service, it appears to me that every thinking person who gives the matter a thorough study ought to be convinced that there is only one proper method of handling it, and that is that all services from the street main to the meter or to the controlling valve on the consumer's premises (including making the tap and setting the meter) should be installed by the employees of the water works, in order to insure proper materials, location, grade, depth, work, etc.

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* Superintendent, Water Works, Taunton, Mass.
† Water Registrar, Springfield, Mass.

In considering the subject, my point of view is naturally mostly that of the municipal water works rather than the private one.

In Springfield we have always made the consumer pay the cost of the tap, the entire service, and the meter installed; this being the original method adopted and handed down ever since as a legacy. This method is the cause of misunderstandings and some friction at times. The custom of laying the main distribution pipes in one side of the street, instead of in the center, makes an unjust discrimination in cost of services as between the consumer on the short side and the consumer on the long side of the street; and in some avenues and thoroughfares of unusual width this discrimination is much worse than in the ordinary streets. I have been free to acknowledge the injustice of this method of cost to inquiring consumers, and have recommended in my reports to our Board of Water Commissioners that, when the change can be made practically and economically, the cost of so much of service installations as lie between the main pipe and the property line be borne by the water works, instead of by the consumers directly. This should also include the meters and their installation. I am convinced that both the street portions of all services, as well as the meters, should be included in the capital costs and assets of every water works, whether municipally or privately owned.

In other words, the rates should be sufficient to take care of such capital costs, and if not sufficient they should be increased. I believe these matters are regulated for the privately owned water utilities by the public utilities commissioners or bodies in different States, and that most of the public utility accountants recommend this method.

One fruitful cause of irritation and misunderstanding is the insistence of payment by the consumer for the *renewal* of his service pipe when it becomes filled up and needs replacing, this being the logical requirement if he has to pay for the first installing of his service. The arguments in such cases have to be somewhat as follows: "Inasmuch as you paid for the tap and service, when first installed, why shouldn't you pay for the replacement of same when its ordinary life is ended, in the same manner as you pay for replacing your furniture, clothing, etc., when worn out?" But such arguments are seldom satisfactory, either to the consumer or to the waterworks official who has to use them.

The tap at the street main has been referred to today as the point of delivery of water supply to the consumer. I have always understood that the *legal point* of such delivery is at the meter, wherever the same may be located, either by a municipality or a private company. I believe there have been court decisions, as well as utterances of the various Public Service or Utility Commissions of the country, to this effect. If this is correct, it should have a bearing upon the separation of capital costs and private costs in furnishing water supply to consumers.

Again referring to the matter of water rates, I am convinced that every municipally owned water works (or utility) should be entirely self-support-

ing, and that its water rates should be readjusted, if need be, so as to insure this result. Where the tax levy has to be called upon to meet deficits of operating costs, etc., it must be a sure indication that such water works is not being administered in as economical or business-like manner as a privately owned one has to be, in order to satisfy its owners, the stockholders, and the public as well.

MR. FRED L. CUSHING.* The city of Medford is going on the principle of furnishing water, and has arrived at the position Mr. McLean states, — that the water supply is at the water main. This is the third year now that we have been charging for the total cost of the service from the main and requiring that the city run the service from the water main into the cellar. We came to this idea because of the inequalities in the situations. We found that some service required a large outlay, where there was rock work, in furnishing water to the line. We had to do something to pay the increased costs, either to get more water rates or borrow money, and we did not want to do either.

We have carried out our idea of requiring a deposit for the estimated cost of the service, entirely from the water main to the cellar, and they pay for it in advance, we refunding them any unexpended balance. It seems to work out very well. The water-taker is very well aware that the service is his, and he can have what he wants, and pays only for what he gets. He can have a large or small service, and as good as he wants.

We believe that the water system ends as far as the municipality goes at the water main, and that the service should be paid for by the taker and maintained by the taker, unless it be a break in the street area, which of course we have to look after. If there is a break in the street, it is taken care of immediately by the city, but if there is a break anywhere else, or stoppage anywhere, the water-taker has to pay the expense in advance. The chronic fault-finding is thus avoided to a great extent.

MR. H. T. GIDLEY.† In our town of Fairhaven we do a little differently than I have heard of here today. Our stopping-point is just inside the curb. We take care of new services and repairs in the street, and the consumer pays for the service across the sidewalk and into the cellar.

MR. HOY. A pipe-pushing machine has been spoken of. In looking around I notice a man in the room who has had some experience along that line. We have had some experience in Worcester, but the nature of the soil makes it impossible to use the machine that is manufactured in Davis City, Nebraska. We have tried it out. Mr. Classon is here and he can probably tell us something about it. It is a machine that was used by the United States Government over in France extensively, as he has intimated to me, and he has had some experience with it.

MR. W. G. CLASSON.‡ This machine is manufactured by the Easy Manufacturing Company, Davis City, Neb.

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* Water Registrar, Medford, Mass.

† Superintendent, Fairhaven Water Co., Fairhaven, Mass.

‡ Superintendent, Water Works, Leominister Mass.

STATISTICS OF MASSACHUSETTS WATER SUPPLIES.

Readers are asked to notify the editor of any errors or omissions in these statistics.

Note: All drainage areas include surface area of pond or reservoir.

Metropolitan Water District.

City or Town.	Population in 1920.	Owned by.	Original System Introduced.	Miles of Pipe.	Services in Use, 1922.*	Meters in Use, 1922*.	Per cent. Services Metered.
Arlington	18 665	Town	1872	52.45	3 643	3 643	100.
Belmont	10 749	Town	1887	35.59	2 263	2 263	100.
Boston	748 060	City	1848	882.76	107 543	75 125	69.9
Chelsea	43 184	City	1867	44.70	5 364	5 333	99.4
Everett	40 120	City	1867	51.36	6 220	4 958	79.7
Lexington	6 350	Town	1884	39.86	1 473	1 460	99.1
Malden	49 103	City	1870	96.27	8 639	8 240	95.4
Medford	39 038	City	1870	75.04	. . . .	. . . .	. . . .
Melrose	18 204	City	1870	55.15	4 420	4 408	99.7
Milton	9 382	Town	1885	53.65	2 443	2 443	100.
Nahant	1 318	Town	1885	21.73	846	615	72.7
Quincy	47 876	City	1884	143.00	11 812	10 660	90.2
Revere	28 823	City	1884	59.57	5 227	4 409	84.3
Somerville	93 091	City	1867	98.26	13 895	11 568	83.2
Stoneham	7 873	Town	1883	27.05	1 724	1 724	100.
Swampscott	8 101	Town	1885	26.41	2 096	2 096	100.
Watertown	21 457	Town	1885	42.67	3 626	3 626	100.
Winthrop	15 455	Town	1884	33.40	3 103	3 089	99.5

* 1923 figures not available, May, 1924.

Sources: —

Pond or Reservoir.	Area.	
	Watershed.	Water Surface.
Wachusett Reservoir	108 Square miles	6.46 Square miles
Sudbury Reservoir	22.28 " "	2.21 " "
Framingham Reservoir No. 1	1.84 " "	0.23 " "
Framingham Reservoir No. 2	28.50 " "	0.21 " "
Framingham Reservoir No. 3	5.40 " "	0.39 " "
Whitehall Reservoir	4.35 " "	0.94 " "
Hopkinton Reservoir	5.86 " "	0.30 " "
Ashland Reservoir	6.43 " "	0.27 " "
Lake Cochituate (a)	17.58 " "	1.14 " "
Farm Pond (a)	0.54 " "	0.26 " "

(a) Emergency supply.

Mode of Supply: — Gravity to Chestnut Hill; Pumping stations at Chestnut Hill, Spot Pond, Arlington, and Hyde Park. Portion of District supplied by gravity from Weston Aqueduct.

Pumpage: — By steam.

Supply guarded by Rules and Regulations of State Department of Public Health.

1. ABINGTON AND ROCKLAND.

Owned by Town.
Introduced: 1887.
Population (1920): Abington, 5 787; Rockland, 7 544. Total, 13 331.
Source: Great Sandy Bottom Pond.
Drainage area: 0.6 square mile.
Surface area of pond: 0.18 square mile.
Water pumped by steam.
Services in use (1922): Abington, 1 283; Rockland, 1 655; Joint, 98. Total, 3 036.
Per cent of services metered (1922): about 95.
Supply is guarded by rules and regulations of State Department of Public Health.

2. ACTON.

Owned by West & South Water Supply District.
Introduced: 1912.
Population (1920): 2 162.
Source: Tubular wells.
Water pumped using fuel oil.
Miles of pipe (1923): 13.5.
Services in use (1923): 431.
Meters in use (1923): 420.
Per cent of services metered (1923): 98.

3. ACUSHNET.

Owned by Town.
Introduced: 1916.
Population (1920): 3 075.
Source: Surface water, obtained from New Bedford water supply.
Miles of pipe (1922): 3.9.
Services in use (1922): 265.
Meters in use: 0.

4. ADAMS.

Owned by Adams Fire District.
Introduced: 1874.
Population (1920): 12 367.
Source: Reservoirs on Bassett and Dry brooks and tubular wells.
Drainage area: Dry Brook Reservoir, 7.8 square miles; Bassett Brook Reservoir, 2.6 square miles.
Surface area of Dry Brook Reservoir, 0.5 square mile; Bassett Brook Reservoir, 0.5 square mile.
Water from reservoirs by gravity and pumped from tubular wells by steam and by electricity.
Miles of pipe (1923): 27.0.
Services in use (1923): 1 887.
Meters in use (1923): 85.
Per cent of services metered (1923): 5.
Supply is guarded by rules and regulations of State Department of Public Health.

5. AGAWAM.

Owned by Town.
Introduced: 1877.
Population (1920): 5 023.
Source: Springfield Water Supply.
Miles of pipe (1918): 30.75.
Services in use (1918): 653.
Meters in use (1918): 645.
Per cent of services metered (1918): 99.

6. AMESBURY.

Owned by Town.
Introduced: 1885.
Population (1920): 10 036.
Source: Tubular wells, and dug well for fire protection.
Water pumped by electricity.
Miles of pipe (1919): 25.
Services in use (1923): 1 788.
Meters in use (1923): 350.
Per cent of services metered (1923): 20.

7. AMHERST.

Owned by Amherst Water Company.
Introduced: 1880.
Population (1920): 5 550.
Source: Three reservoirs on Amethyst Brook.
Drainage area: New storage reservoir, 4.25 square miles; old storage reservoir, 1.7 square miles; intake reservoir, 6.3 square miles.
Surface area of reservoirs: new storage reservoir, 5 acres; old storage reservoir, 6 acres; intake reservoir, 0.75 acre.
Water supplied by gravity.
Miles of pipe (1923): 33.7.
Services in use (1923): 1 216.
Meters in use (1923): 1 207.
Per cent of services metered (1923): 99.
Supply is guarded by rules and regulations of State Department of Public Health.

8. ANDOVER.

Owned by Town.
Introduced: 1890.
Population (1920): 8 268.
Source: Haggett's Pond.
Drainage area: 2.7 square miles.
Surface area: 0.31 square mile.
Water is pumped by steam.
Miles of pipe (1923): 56.
Services in use (1923): 1 950.
Meters in use (1923): 1 856.
Per cent of services metered (1923): 95.
Supply is guarded by rules and regulations of State Department of Public Health.

9. ARLINGTON.

See Metropolitan Water District.

10. ASHBURNHAM.

Owned by Town.
Introduced: 1870.
Population (1920): 2 012.
Source: Upper Naukeag Pond.
Drainage area: 2.07 square miles.
Surface area of pond: 0.41 square mile.
Water is pumped by electricity.
Miles of pipe (1923): 9.
Services in use (1923): 340.
Meters in use (1923): 320.
Per cent of services metered (1923): 94.
Supply is guarded by rules and regulations of State Department of Public Health.

11. ASHFIELD.

Owned by Ashfield Water Company.
Introduced: 1904.
Population (1920): 869.
Source: Reservoir on Bear Swamp Brook.
Drainage area: 0.45 square mile.
Surface area of reservoir: 3 acres.
Water supplied by gravity.
Miles of pipe (1923): 2.9.
Services in use (1923): 74.
Meters in use (1923): 0.
Per cent of services metered (1923): 0.
Supply is guarded by rules and regulations of State Department of Public Health.

12. ASHLAND.

Owned by Town.
Introduced: 1911.
Population (1920): 2 287.
Source: Tubular wells.
Water pumped by electric power.
Miles of pipe (1923): 8.2.
Services in use (1923): 340.
Meters in use (1923): 403.
Per cent of services metered (1923): 100.

13. ATHOL.

Owned by Town.
Introduced: 1875.
Population (1920): 9 792.
Source: Phillipston Brook Reservoir (mechanical filters); Thousand Acre Meadow Brook Reservoir (slow sand filters); Newton Reservoir (slow sand filters); Emergency — Lake Ellis.
Drainage area: Phillipston Reservoir, 0.66 square mile; Thousand Acre Reservoir, 2.4 square miles; Newton Reservoir, 0.95 square mile; Lake Ellis, 3.2 square miles.

Surface area of reservoirs and lake: Phillipston Reservoir, 0.26 square mile; Thousand Acre Reservoir, 0.48 square mile; Newton Reservoir, 0.023 square mile; Lake Ellis, 0.102 square mile.
Water from Phillipston Brook, Thousand Acre and Newton reservoirs by gravity; from Lake Ellis pumped.
Miles of pipe (1923): 34.
Services in use (1923): 1 600.
Meters in use (1923): 77.
Per cent of services metered (1923): 5.

14. ATTLEBORO.

Owned by City.
Introduced: 1873.
Population (1920): 19 731.
Source: Two wells, filter gallery and impounded waters of Seven Mile River. (Ground about filter gallery flooded by water from Seven Mile River or by pumping from Orr's Pond.)
Water pumped by steam.
Miles of pipe (1918): 68.5.
Services in use (1923): 3 086.
Meters in use (1923): 3 086.
Per cent of services metered (1923): 100.
Supply is guarded by rules and regulations of State Department of Public Health.

15. AUBURN.

Owned by Auburn Water Company.
Introduced: 1920.
Population (1920): 3 891.
Source: Tubular wells.
Water is pumped by electricity.
Miles of pipe (1923): 6.1.
Services in use (1923): 155.
Meters in use (1923): 110.
Per cent of services metered (1923): 71.

16. AVON.

Owned by Town.
Introduced: 1890.
Population (1920): 2 176.
Source: Three wells, — 1 dug and 2 deep.
Water is pumped by steam.
Miles of pipe (1923): 8.5.
Services in use (1923): 514.
Meters in use (1923): 242.
Per cent of services metered (1923): 47.

17. AYER.

Owned by Town.
Introduced: 1887.
Population (1920): 3 052.
Source: Tubular wells and dug well.
Water pumped by electricity.

Miles of pipe (1920): 12.5.
Services in use (1923): 669.
Meters in use (1923): 491.
Per cent of services metered (1923): 73.

18. BARNSTABLE.

Owned by Barnstable Water Company.
Introduced: 1912.
Population (1920): 4 836.
Source: Tubular wells.
Water is pumped using fuel oil.
Miles of pipe (1923): 15.9.
Services in use (1923): 779.
Meters in use (1923): 29.
Per cent of services metered (1923): 4.

19. BARRE.

Owned by Town.
Introduced: 1895.
Population (1920): 3 357.
Source: Reservoir on Allen Hill.
Drainage area: 0.43 square mile.
Surface area of reservoir: 4.25 acres.
Water supplied by gravity.

20. BEDFORD.

Owned by Town.
Introduced: 1909.
Population (1920): 1 362.
Source: Dug well and filtered water of Kenrick's Pond.
Water pumped by electricity.
Miles of pipe (1923): 9.6.
Services in use (1923): 280.
Per cent of services metered: 75 approx.

21. BELMONT.

See Metropolitan Water District.

22. BEVERLY.

Owned by City (joint supply with Salem).
Introduced: 1868.
Population (1920): 22 561.
Source: Wenham Lake and Longham Reservoir; emergency supply from Ipswich River (chlorinator).
Water from Wenham Lake pumped by steam and electricity; from Ipswich River by electricity.
Drainage area: Wenham Lake, 2.53 square miles; Longham Reservoir, 3.28 square miles.
Surface area: Wenham Lake, 0.39 square mile; Longham Reservoir, 0.14 square mile.
Miles of pipe (1923): 86.7.
Services in use (1923): 5 042.
Meters in use (1923): 3 535.
Per cent of services metered (1923): 70.
Supply is guarded by rules and regulations of State Department of Public Health.

23. BILLERICA.

Owned by Town.
Introduced: 1898.
Population (1920): 3 646.
Source: Tubular wells.
Water is pumped by steam.
Miles of pipe (1923): 25.0.
Services in use (1923): 700.
Meters in use (1923): 700.
Per cent of services metered: 100.

24. BLACKSTONE.

Owned by Town.
Introduced: 1911.
Population (1920): 4 299.
Source: Woonsocket, R. I., water system.
Water is pumped.

25. BLANDFORD.

Owned by Blandford Fire District.
Introduced: 1909.
Population (1920): 479.
Source: Reservoir on Freeland Brook.
Drainage area: 0.14 square mile.
Surface area of reservoir: 0.05 acre.
Water pumped.
Services in use (1923): 90.
Meters in use (1923): 90.
Per cent of services metered (1923): 100.

26. BOSTON.

See Metropolitan Water District.

27. BOURNE.

Owned by Monument Beach Water Company.
Population (1920): 2 530.
Source: Tubular wells.
Water is pumped using fuel oil.

28. BRAINTREE.

Owned by Town.
Date introduced: 1887.
Population (1920): 10 580.
Source: Great Pond; auxiliary supply from filter gallery on Little Pond. Chlorinators installed.
Drainage area: Great Pond, 3.44 square miles; Little Pond, 0.51 square mile.
Surface area of ponds: Great Pond, 157 acres; Little Pond, 72 acres.
Water pumped by steam from Great Pond; by electricity from Little Pond.
Miles of pipe (1923): 54.
Services in use (1923): 2 620.
Meters in use (1923): 2 401.
Per cent of services metered (1923): 92.
Supply is guarded by rules and regulations of State Department of Public Health.

29. BRIDGEWATER.

Owned by Bridgewater Water Company.
Introduced: 1888.
Population (1920): 8 438.
Source: Tubular wells.
Water is pumped by fuel oil.
Miles of pipe (1922): 18.6.
Services in use (1922): 965.
Meters in use (1922): 631.
Per cent of services metered (1922): 65.

30. BROCKTON.

Owned by City.
Introduced: 1880.
Population (1920): 66 254.
Source: Silver Lake.
Drainage area: 4.39 square miles.
Surface area of lake: 1.01 square miles.
Water is pumped by steam.
Miles of pipe (1920): 127.
Services in use (1923): 10 576.
Meters in use (1923): 10 405.
Per cent of services metered (1923): 98.
Supply is guarded by rules and regulations of State Department of Public Health.

31. BROOKFIELD.

Owned by Town.
Introduced: 1889.
Population (1920): 2 216.
Source: Reservoir on Cooley Hill and dug well. Emergency supply from two dug wells.
Drainage area: 75 acres.
Surface area of reservoir: 1.75 acres.
Water from reservoir by gravity; pumped from well by electricity.
Services in use (1921): 200.
Meters in use (1921): 85.
Per cent of services metered (1921): 43.

32. BROOKLINE.

Owned by Town.
Introduced: 1875.
Population (1920): 37 748.
Source: Tubular wells (iron removal plant).
Water is pumped by steam.
Miles of pipe (1923): 101.
Services in use (1923): 6 455.
Meters in use (1923): 6 455.
Per cent of services metered (1923): 100.

33. CAMBRIDGE.

Owned by City.
Introduced: 1856.
Population (1920): 109 694.
Source: Stony Brook Reservoir; Hobbs Brook Reservoir; Fresh Pond; all water filtered (mechanical filters). Chlorinator installed.
Drainage area: Hobbs Brook Reservoir, 7.25 square miles; Stony Brook Reservoir, 23.57 square miles (including Hobbs); Fresh Pond, 1.25 square miles.
Surface area of pond and reservoirs; Hobbs Brook Reservoir, 558 acres; Stony Brook Reservoir, 72 acres; Fresh Pond, 166 acres.
Water to Fresh Pond by gravity; pumped from there by steam.
Miles of pipe (1923): 136.6.
Services in use (1923): 15 243.
Meters in use (1923): 7 378.
Per cent of services metered (1923): 48.
Supply is guarded by rules and regulations of State Department of Public Health.

34. **CANTON.**

Owned by Town.
Introduced: 1889.
Population (1920): 5 945.
Source: Tubular wells and two large wells.
Water is pumped by steam.
Miles of pipe (1919): 31.

35. CHELMSFORD.

Owned by Chelmsford Water District.
Introduced: 1914.
Population (1920): 5 682.
Source: Tubular wells.
Water is pumped by fuel oil.
Miles of pipe (1923): 11.9.
Services in use (1923): 486.
Meters in use (1923): 461.
Per cent of services metered: 95.

36. CHELMSFORD.

Owned by North Chelmsford Fire District.
Introduced: 1907.
Population (1920): 5 682.
Source: Tubular wells.
Water pumped by electricity.
Miles of pipe (1923): 7.
Services in use (1923): 476.
Meters in use (1923): 358.
Per cent of services metered (1923): 75.

37. CHELSEA.

See Metropolitan Water District.

38. CHESHIRE.

Owned by Cheshire Water Company.
Introduced: 1876.
Population (1920): 1 476.
Source: Reservoirs on Kitchen and Thunder brooks.
Drainage area: Thunder Brook, 1.65 square miles: Kitchen Brook, 2.46 square miles.
Surface area of reservoirs: Thunder Brook, 0.2 acre; Kitchen Brook, 0.2 acre.
Water by gravity.
Miles of pipe (1923): 7.
Services in use (1923): 224.
Meters in use (1923): 0.
Per cent of services metered (1923): 0.

39. CHESTER.

Owned by Chester Fire District.
Introduced: 1893.
Population (1920): 1 302.
Source: Reservoir on Austin Brook and Horn Pond.
Drainage area: Austin Brook Reservoir, 1.25 square miles; Horn Pond, 0.45 square mile.
Surface area of pond and reservoir: Horn Pond, 0.05 square mile.
Water by gravity.
Supply is guarded by rules and regulations of State Department of Public Health.

40. CHICOPEE.

Owned by City.
Introduced: 1845.
Population (1920): 36 214.
Source: Morton Brook Reservoir; Cooley Brook Reservoir; Abbe Brook Reservoir; tubular wells.
Drainage area: Morton Brook Reservoir, 0.35 square mile; Cooley Brook Reservoir, 4.55 square miles; Abbe Brook Reservoir, 0.75 square mile.
Surface area of reservoirs: Morton Brook Reservoir, 4 000 square feet; Cooley Brook Reservoir, 3 acres; Abbe Brook Reservoir, 3.5 acres.
Water from Abbe Brook Reservoir by gravity; pumped by electricity from Morton Brook and Cooley reservoirs and from wells.
Miles of pipe (1923): 83.2.
Services in use (1923): 4 559.
Meters in use (1923): 3 791.
Per cent of services metered (1923): 83.
Supply is guarded by rules and regulations of State Department of Public Health.

41. CLINTON.

Owned by Town.
Introduced: 1882.
Population (1920): 12 979.
Source: Upper and Lower Lynde's reservoirs; Spring Basin; Heywood Pond; emergency connection, pipe line from Wachusett Reservoir.
Drainage area: Upper Lynde's Reservoir, Lower Lynde's Reservoir and Spring Basin, 0.96 square mile; Heywood Pond, 0.75 square mile.

Surface area of pond and reservoirs: Upper Lynde's Reservoir, 7 acres: Lower Lynde's Reservoir, 4 acres; Spring Basin, 3 acres; Heywood Pond, 45 acres.
Water by gravity except in case of emergency connection, which is electrically pumped.
Miles of pipe (1923): 38.5.
Services in use (1923): 2 087.
Meters in use (1923): 1 852.
Per cent of services metered (1923): 89.

42. COHASSET.

Owned by Cohasset Water Company.
Introduced: 1886.
Population (1920): 2 639.
Source: Tubular wells; large dug well (water from Lily Pond pumped to ground about well); filter gallery near Lily Pond; iron removal plant at large dug well.
Water is pumped by electricity and fuel oil engine.
Miles of pipe (1923): 18.4.
Services in use (1923): 779.
Meters in use (1923): 48.
Per cent of services metered (1923): 6.
Supply is guarded by rules and regulations of State Department of Public Health.

43. COLRAIN.

Owned by Colrain Fire District No. 1.
Introduced: 1902.
Population (1920): 1 607.
Source: Reservoir on Mountain Brook.
Drainage area: 0.75 square mile.
Surface area of pond or reservoir: 0.2 acre.
Water by gravity.
Services in use: 26.
Meters in use: 26.
Per cent of services metered: 100.

44. COLRAIN (Griswoldville).

Owned by Griswoldville Manufacturing Company.
Introduced: 1901.
Source: Reservoir on McClellan Brook.
Drainage area: 0.44 square mile.
Water by gravity.

45. CONCORD.

Owned by Town.
Introduced: 1873.
Population (1920): 6 461.
Source: Sandy and Nagog ponds.
Drainage area: Sandy Pond, 0.72 square mile; Nagog Pond, 1.52 square miles.
Surface area of ponds: Sandy Pond, 0.25 square mile; Nagog Pond, 0.45 square mile.

Water for low service by gravity; for high service pumped by electricity.
Miles of pipe (1923): 48.4.
Services in use (1923): 1 420.
Meters in use (1923): 60.
Per cent of services metered (1923): 4.
Supply is guarded by rules and regulations of State Department of Public Health.

46. CUMMINGTON.

Owned by Town.
Introduced: 1916.
Population (1920): 489.
Source: Tubular wells.
Water is pumped by steam and by water power.

47. DALTON.

Owned by Dalton Fire District.
Introduced: 1884.
Population (1920): 3 752.
Source: Intake reservoirs on May Brook, Cady Brook, Egypt Brook, Beals Brook, Anthony Brook; auxiliary supply from Windsor Reservoir.
Drainage areas: Egypt Brook Reservoir, 1.4 square miles; Cady Brook Reservoir, 3.6 square miles; May Brook Reservoir, 2.2 square miles; Anthony Brook Reservoir, 1.4 square miles; Windsor Reservoir, 15.2 square miles.
Surface area of reservoirs: Egypt Brook Reservoir, 4.4 acres; Windsor, 0.12 square mile.
Water supplied by gravity.
Miles of pipe (1923): 5.
Services in use (1923): 969.
Meters in use (1923): 0.
Per cent of services metered (1923): 0.
Supply is guarded by rules and regulations of State Department of Public Health.

48. DANVERS AND MIDDLETON.

Owned by Towns.
Introduced: 1876.
Population (1920): Danvers, 11,108; Middleton, 1, 195; total 12,303.
Source: Swan and Middleton ponds.
Drainage areas: Middleton Pond, 1.63 square miles; Swan Pond, 0.18 square mile.
Surface area of ponds: Middleton Pond, 0.23 square mile; Swan Pond, 0.07 square mile.
Water pumped from Middleton Pond by steam; from Swan Pond by electricity.
Miles of pipe (1923): 61.7.
Services in use (1923): 2 400.
Meters in use (1923): 211.
Per cent of services metered (1923): 9.
Supply is guarded by rules and regulations of State Department of Public Health.

49. DARTMOUTH.

Owned by Town.
Introduced: 1915.
Population (1920): 6 493.
Source: New Bedford Water System.

50. DEDHAM.

Owned by Dedham Water Company.
Introduced: 1881.
Population (1920): 10 792.
Source: Tubular and dug wells.
Water is pumped by steam.
Miles of pipe (1923): 42.7.
Services in use (1923): 2 653.
Meters in use (1923): 2 445.
Per cent of services metered (1923): 92.

51. DEERFIELD, South.

Owned by South Deerfield Water Supply District.
Introduced: 1903.
Source: Reservoir on Roaring Brook.
Drainage area: 4.0 square miles.
Surface area of reservoir: 0.76 acre.
Water by gravity.

52. DEERFIELD.

Owned by Deerfield Fire District.
Introduced: 1911.
Source: Two springs; auxiliary supply from shallow wells.
Water from springs by gravity; auxiliary supply pumped by electricity.

53. DOUGLAS.

Owned by Town.
Introduced: 1910.
Population (1920): 2 181.
Source: Tubular wells.
Water pumped by electricity.

54. DRACUT.

Owned by Dracut Water Supply District.
Introduced: 1906.
Population (1920): 5 280.
Source: Tubular wells.
Water pumped by Otto gas.
Miles of pipe (1923): 12.7.
Services in use (1923): 519.
Meters in use (1923): 127.
Per cent of services metered: 24.

55. DRACUT (Collinsville).

Owned by American Woolen Company.
Introduced: 1900.
Source: Wells.
Water pumped by electricity.

56. DUDLEY.

Owned by Town.
Introduced: 1910.
Population (1920): 3 701.
Source: Tubular wells.
Water is pumped by electricity.
Miles of pipe (1923): 10.
Services in use (1923): 362.
Meters in use (1923): 362.
Per cent of services metered (1923): 100.

57. DUNSTABLE.

Owned by Town.
Introduced: 1918.
Population (1920): 353.
Source: Dug well.
Water is pumped by gasoline.
Miles of pipe (1923): 1.0.
Services in use (1923): 10.
Meters in use (1923): 10.
Per cent of services metered (1923): 100.

58. DUXBURY.

Owned by Duxbury Fire and Water District.
Introduced: 1914.
Population (1920): 1 553.
Source: Tubular wells.
Water is pumped by fuel oil.
Miles of pipe (1923): 17.
Services in use (1923): 564.
Meters in use (1923): 559.
Per cent of services metered (1923): 99.

59. EAST BRIDGEWATER.

Owned by Town.
Introduced: 1888.
Population (1920): 3 486.
Source: Bridgewater, W. Bridgewater and Brockton water supplies.
Services in use (1923): 770.
Meters in use (1922): 706.
Per cent of services metered (1922): 95.

60. EAST BROOKFIELD.

Owned by Town.
Introduced: 1908.
Source: Tubular wells and one dug well.
Water pumped by electricity and fuel oil.
Miles of pipe (1923): 2.25.
Services in use (1923): 138.
Meters in use (1923): 87.
Per cent of services metered (1923): 63.

61. EAST FOXBOROUGH.

See Foxborough.

62. EAST LONGMEADOW.

Owned by Town.
Introduced: 1913.
Population (1920): 2 352.
Source: Springfield Water Supply.
Miles of pipe (1922): 8.9.
Services in use (1922): 330.
Meters in use (1918): 243.
Per cent of services metered (1918): 99.
Supply is guarded by rules and regulations of State Department of Public Health.

63. EASTHAMPTON.

Owned by Town.
Introduced: 1870.
Population (1920): 11 261.
Source: Tubular wells.
Water pumped by steam and by water power.
Miles of pipe (1923): 37.
Services in use (1923): 1 950.
Meters in use (1923): 1 950.
Per cent of services metered (1923): 100.
Supply is guarded by rules and regulations of State Department of Public Health.

64. EASTON. (Supplies also Unionville Fire and Water District.)

Owned by North Easton Village District.
Introduced: 1887.
Source: Dug well and reservoir fed by spring and mill pond on Queset River.
Drainage area: 2.72 square miles.
Surface area of reservoir: 0.2 square mile.
Water pumped by steam.
Miles of pipe (1923): 10.5.
Services in use (1923): 616.
Meters in use (1923): 656.
Per cent of services metered (1923): 100.

65. EASTON.

Owned by South Easton and Eastondale Fire and Water District.
Introduced: 1915.
Source: Brockton Water Supply.
Miles of pipe (1917): 13.0.

66. EDGARTOWN.

Owned by Edgartown Water Company.
Introduced: 1906.
Population (1920): 1 190.
Source: Large well.
Water pumped by kerosene.
Miles of pipe (1923): 6.7.
Services in use (1923): 450.
Meters in use (1923): 4.
Per cent of services metered (1923): 1.

67. EGREMONT.

Owned by South Egremont Water Company.
Introduced: 1913.
Population (1920): 441.
Source: Intake reservoir on Goodale Brook.
Drainage area: 2.5 square miles.
Surface area of reservoir: 0.1 acre.
Water by gravity.
Miles of pipe (1923): 4.2.
Services in use (1923): 54.
Meters in use (1923): 7.
Per cent of services metered (1923): 13.

68. EVERETT.

See Metropolitan Water District.

69. FAIRHAVEN.

Owned by Fairhaven Water Company.
Introduced: 1894.
Population (1920): 7 291.
Source: Tubular wells.
Water pumped by steam and by electricity.
Miles of pipe (1922): 25.4.
Services in use (1923): 1 984.
Meters in use (1923): 0.
Per cent of services metered (1923): 0.

70. FALL RIVER.

Owned by City.
Introduced: 1874.
Population (1920): 120 485.
Source: North Watuppa Pond.
Drainage area: 9.14 square miles.
Surface area of pond: 2.82 square miles.
Water pumped by steam.
Miles of pipe (1923): 137.2.
Services in use (1923): 11 422.
Meters in use (1923): 11 421.
Per cent of services metered: 100.
Supply is guarded by rules and regulations of State Department of Public Health.

71. FALMOUTH.

Owned by Town.
Introduced: 1899.
Population (1920): 3 500.
Source: Long Pond.
Drainage area: 1.12 square miles.
Surface area of pond: 0.34 square mile.
Water pumped by steam.
Miles of pipe (1923): 71.
Services in use (1923): 1 812.
Meters in use (1923): 25.
Per cent of services metered: 1.
Supply is guarded by rules and regulations of State Department of Public Health.

72. FITCHBURG.

Owned by City.
Introduced: 1872.
Population (1920): 41 029.
Source: Meetinghouse Pond, Wachusett Lake, Scott Reservoir, Ashby Reservoir, Falulah Reservoir.
Drainage area: Meetinghouse Pond, 1.47 square miles; Wachusett Lake, 1.52 square miles; Ashby Reservoir, 2.16 square miles; Scott Reservoir, 500 acres; Fululah Reservoir, 2.406 acres.
Surface area of pond and reservoirs: Meetinghouse, 0.24 square mile; Wachusett Lake, 0.18 square mile; Ashby Reservoir, 0.24 square mile; Scott Reservoir, 35 acres; Falulah Reservoir, 3.6 acres.
Water by gravity.
Miles of pipe (1923): 90.5.
Services in use (1923): 6 195.
Meters in use (1923): 5 510.
Per cent of services metered (1923): 89.
Supply is guarded by rules and regulations of State Department of Public Health.

73. FOXBOROUGH. (Supplies also East Foxborough Water Supply District.)

Owned by Foxborough Water Supply District.
Introduced: 1891.
Source: Tubular wells.
Water pumped by steam.
Services in use (1923): 714.
Per cent of services metered (1923): approx. 90.

74. FRAMINGHAM.

Owned by Town.
Introduced: 1885.
Population (1920): 17 033.
Source: Filter galleries near Farm Pond; Sudbury Aqueduct; chlorinator installed.
Water pumped by steam.
Miles of pipe (1923): 59.
Services in use (1923): 3 067.
Meters in use (1923): 3 213.
Per cent of services metered (1923): 100.

75. FRANKLIN.

Owned by Town.
Introduced: 1884.
Population (1920): 6 497.
Source: Tubular wells.
Water pumped by electricity.
Miles of pipe (1923): 35.
Services in use (1923): 1 167.
Meters in use (1923): 1 167.
Per cent of services metered (1923): 100.

76. GILL.

Owned by Riverside Water Company.
Introduced: 1888.
Population (1920): 879.
Source: " Heal All " Spring.
Water by gravity.
Miles of pipe (1923): 4.8.
Services in use (1923): 47.
Meters in use (1923): 0.
Per cent of services metered (1923): 0.

77. GARDNER.

Owned by City.
Introduced: 1882.
Population (1920): 16 971.
Source: Crystal Lake and Intake Reservoir on Perley Brook.
Drainage area: Crystal Lake, 0.95 square mile; Perley Brook, 2.75 square miles.
Surface area of reservoirs: Crystal Lake, 0.24 square mile; Perley Brook, 3 acres.
Water pumped by steam and by electricity.
Miles of pipe (1923): 34.2.
Services in use (1923): 2 503.
Meters in use (1923): 2 402.
Per cent of services metered (1923): 96.
Supply is guarded by rules and regulations of State Department of Public Health.

78. GLOUCESTER.

Owned by City.
Introduced: 1885.
Population (1920): 22 947.
Source: Wallace Reservoir, Haskell Reservoir, Dike's Meadow Reservoir.
Drainage area: Wallace Reservoir, 0.29 square mile; Haskell Reservoir, 0.64 square mile; Dike's Reservoir, 0.68 square mile.
Surface area of reservoirs: Wallace Reservoir, 24.6 acres; Haskell Reservoir, 62.4 acres; Dike's Reservoir, 57.6 acres.
Water pumped by steam.
Miles of pipe (1923): 66.8.
Services in use (1923): 5 394.
Meters in use (1923): 487.
Per cent of services metered (1923): 9.

79. GRAFTON.

Owned by Grafton Water Company.
Introduced: 1910.
Population (1920): 6 887.
Source: Dug wells.
Water pumped by steam.
Miles of pipe (1923): 9.8.
Services in use (1923): 403.
Meters in use (1923): 43.
Per cent of services metered (1923): 11.

80. GRANVILLE.

Owned by Granville Centre Water Company.
Introduced: 1910.
Population (1920): 655.
Source: Well.
Water supplied by gravity.
Miles of pipe (1923): 1.1.
Services in use (1923): 18.
Meters in use (1923): 16.
Per cent of services metered (1923): 89.

81. GREAT BARRINGTON.

Owned by Great Barrington Fire District.
Introduced: 1867.
Source: Reservoir on East Mountain; well and filter gallery on Green River.
Water from East Mountain Reservoir by gravity; pumped from Green River by electricity.
Miles of pipe (1923): 23.
Services in use (1923): 1 175.
Meters in use (1923): 30.
Per cent of services metered (1923): 3.

82. GREAT BARRINGTON (Housatonic).

Owned by Housatonic Water Company.
Introduced: 1888.
Source: Long Pond.
Drainage area: 1.04 square miles.
Surface area of pond: 0.22 square mile.
Water supplied by gravity.
Miles of pipe (1922): 13.
Services in use (1922): 550.
Meters in use (1922): 10.
Per cent of services metered (1922): 2.

83. GREENFIELD.

Owned by Town.
Introduced: 1870.
Population (1920): 15 462.
Source: Upper and lower reservoirs on Glen Brook; auxiliary supply from a well and a filter gallery near the Green River. (Ground about filter gallery flooded from river.) Chlorinator, dual installation.
Drainage area: Upper Reservoir, 5.15 square miles; Lower Reservoir, 0.21 square mile.
Surface area of reservoirs: Upper Reservoir, 7.5 acres; Lower Reservoir, 5.7 acres.
Water supplied from reservoirs by gravity; pumped by electricity from river.
Miles of pipe (1923): 54.9.
Services in use (1923): 3 004.
Meters in use (1923): 507.
Per cent of services metered (1923): 17.
Supply is guarded by rules and regulations of State Department of Public Health.

84. GROTON.

Owned by Groton Water Company.
Introduced: 1897.
Population (1920): 2 185.
Source: Well near Buddacook Pond.
Water is pumped by steam.
Miles of pipe (1922): 9.
Services in use (1922): 283.
Meters in use (1922): 292.
Per cent of services metered (1922): 100.

85. GROTON.

Owned by West Groton Water Supply District.
Introduced: 1912.
Source: Tubular wells.
Water is pumped by electricity.
Miles of pipe (1923): 3.
Services in use (1923): 109.
Meters in use (1923): 50.
Per cent of services metered (1923): 46.

86. GROVELAND.

Owned by Town.
Introduced: 1915.
Population (1920): 2 650.
Source: Haverhill Water Supply.
Miles of pipe (1923): 10.
Services in use (1923): 477.
Meters in use (1923): 215.
Per cent of services metered (1923): 45.
Supply is guarded by rules and regulations of State Department of Public Health.

87. HADLEY.

Owned by Hadley Water Supply District.
Introduced: 1905.
Population (1920): 2 784.
Source: Two reservoirs on Upper Harts Brook.
Drainage area: Upper Harts Brook, 0.2 square mile; Lower Harts Brook, 0.1 square mile.
Surface area of Upper Harts Brook, 1 acre; Lower Harts Brook, 0.9 acre.
Water supplied by gravity.
Miles of pipe (1923): 17.
Services in use (1923): 288.
Meters in use (1923): 0.
Per cent of services metered (1923): 0.

88. HARDWICK.

Owned by C. H. Gilbert Manufacturing Company.
Introduced: 1887.
Population (1920): 3 085.
Source: Spring and tubular wells.
Water from spring by gravity; pumped by electricity from wells.

89. HATFIELD.

Owned by Town.
Introduced: 1896.
Population (1920): 2 651.
Source: Reservoir on Running Gutter Brook.
Drainage area: 0.3 square mile.
Surface area of reservoir: 1.2 acres.
Water supplied by gravity.
Services in use (1920): 351.
Meters in use (1920): 0.
Per cent of services metered (1920): 0.

90. HAVERHILL.

Owned by City.
Introduced: 1802.
Population (1920): 53 884.
Source: Millvale Reservoir, Kenoza Lake, Johnson's Pond, Crystal Lake, Pentucket Lake, Lake Saltonstall.
Drainage area: Millvale Reservoir, 7.82 square miles; Kenoza Lake, 1.60 square miles; Crystal Lake, 3.24 square miles; Pentucket Lake, 0.49 square mile; Lake Saltonstall, 0.32 square mile; Johnson's Pond, 5.09 square miles.
Surface area of pond or reservoir; Millvale Reservoir, 0.07 square mile; Kenoza Lake, 0.35 square mile; Crystal Lake, 0.23 square mile; Pentucket Lake, 0.06 square mile; Lake Saltonstall, 0.06 square mile; Johnson's Pond, 0.35 square mile.
Water from Crystal and Pentucket lakes and Lake Saltonstall by gravity; pumped by steam from Millvale Reservoir, Kenoza Lake and Johnson's Pond.
Miles of pipe (1923): 124.
Services in use (1923): 8 828.
Meters in use (1923): 5 532.
Per cent of services metered (1923): 63.
Supply is guarded by rules and regulations of State Department of Public Health.

91. HINGHAM (and HULL).

Owned by Hingham Water Company.
Introduced: 1880.
Population (1920): Hingham, 5 604; Hull, 1 771.
Source: Accord Pond; collecting system near Fulling Mill Pond. (Ground above collecting works flooded with water from Accord Pond.)
Drainage area: Accord Pond, 0.72 square mile.
Surface area of Accord Pond, 93 acres.
Water by gravity from Accord Pond; pumped from collecting well by producer gas and electricity.
Services in use (1923): 4 727.
Meters in use (1923): 131.
Per cent of services metered (1923): 3.
Supply is guarded by rules and regulations of State Department of Public Health.

92. HINSDALE.

Owned by Hinsdale Fire District.
Introduced: 1889.
Population (1920): 1 065.
Source: Reservoir on Steam Sawmill brook.
Surface area of reservoir, 0.014 square mile.
Water supplied by gravity.
Miles of pipe (1920): 5.5.
Services in use (1920): 102.
Meters in use (1920): 0.
Per cent of services metered (1920): 0.

93. HOLBROOK (see **Randolph**).

Owned by Town.
Introduced: 1888.
Population (1920): 3 161.
Drainage area, 3.44 square miles.
Surface area of pond, 157 acres.
Source: Great Pond.
Water pumped by steam.
Services in use (1923): 955.
Meters in use (1923): 74.
Per cent of services metered (1923): 8.
Supply is guarded by rules and regulations of State Department of Public Health.

94. HOLDEN.

Owned by Town.
Introduced: 1905.
Population (1920): 2 970.
Source: Muschopauge Pond.
Drainage area: 0.6 square mile.
Surface area of pond: 60 acres.
Water by gravity.
Miles of pipe (1923): 9.
Services in use (1923): 445.
Meters in use (1923): 378.
Per cent of services metered (1923): 85.
Supply is guarded by rules and regulations of State Department of Public Health.

95. HOLLISTON.

Owned by Holliston Water Company.
Introduced: 1891.
Population (1920): 2 707.
Source: Large well and crib below Talbot's Pond. Chlorinator installed.
Water pumped by steam.
Miles of pipe (1923): 8.7.
Services in use (1923): 301.
Meters in use (1923): 1.
Per cent of services metered (1923): 0.

96. HOLYOKE.

Owned by city.
Introduced: 1873.
Population (1920): 60 203.
Source: Ashley Ponds, High Service Reservoir, Whiting Street Reservoir, Manhan Reservoir.
Drainage area: Ashley Ponds, 1 648 acres; High Service Reservoir, 240 acres; Whiting Street Reservoir, 940 acres; Manhan Reservoir, 13 square miles.
Surface area of pond and reservoirs: Ashley Ponds, 0.45 square mile; High Service Reservoir, 0.10 square mile; Whiting Street Reservoir, 0.19 square mile; Manhan Reservoir, 10.3 acres.
Water by gravity.
Miles of pipe (1923): 102.4.
Services in use (1923): 5 319.
Meters in use (1923): 453.
Per cent of services metered (1923): 9.
Supply is guarded by rules and regulations of State Department of Public Health.

97. HOPEDALE.

See Milford.

98. HOPKINTON.

Owned by Town.
Introduced: 1884.
Population (1920): 2 289.
Source: Deep wells; emergency supply from Whitehall Pond.
Water is pumped by electricity.

99. HUDSON.

Owned by Town.
Introduced: 1884.
Population (1920): 7 607.
Source: Gates Pond, Fosgate Brook.
Drainage area: Gates Pond, 171.3 acres; Fosgate Brook, 104.4 acres.
Surface area of pond: Gates Pond, 83.7 acres.
Water is supplied by gravity.
Miles of pipe (1923): 30.
Services in use (1923): 1 391.
Meters in use (1923): 1 389.
Per cent of services metered (1923): 100.
Supply is guarded by rules and regulations of State Department of Public Health.

100. HULL.

See Hingham.

101. HUNTINGTON.

Owned by Huntington Fire District.
Introduced: 1899.
Population (1920): 1 425.
Source: Cold Brook Reservoir; tubular wells.
Drainage area: 0.94 square mile.
Water by gravity from reservoir; pumped from wells by electricity.

102. IPSWICH.

Owned by Town.
Introduced: 1894.
Population (1920): 6 201.
Source: Reservoir on Dow's Brook; Bull Brook; chlorinators installed.
Drainage area: Dow's Brook, 0.88 square mile; Bull Brook, 3.65 square miles.
Surface area of reservoir: Dow's Brook Reservoir, 0.028 square mile.
Water by gravity from Bull Brook; pumped by steam from Dow's Brook.
Miles of pipe (1923): 28.9.
Services in use (1923): 1 125.
Meters in use (1923): 578.
Per cent of services metered (1923): 51.

103. ISLINGTON.

See Westwood.

104. KINGSTON.

Owned by Town.
Introduced: 1886.
Population (1920): 2 505.
Source: Tubular wells.
Water pumped by steam.
Miles of pipe (1923): 12.5.
Services in use (1923): 646.
Meters in use (1923): 0.
Per cent of services metered (1923): 0.

105. LANCASTER.

Owned by Town.
Introduced: 1885.
Population (1920): 2 461.
Source: Clinton water supply.
Miles of pipe (1921): 19.4.
Services in use (1921): 475.
Meters in use (1921): 450.
Per cent of services metered (1921): 95.

106. LAWRENCE.

Owned by City.
Introduced: 1875.
Population (1920): 94 270.
Source: Merrimac River, filtered (slow sand); chlorinators installed.
Water pumped by steam.
Miles of pipe (1922): 109.5.
Services in use (1923): 9 730.
Meters in use (1923): 9 441.
Per cent of services metered (1923): 97.

107. LEE.

Owned by Berkshire Water Company.
Introduced: 1881.
Population (1920): 4 085.
Source: Reservoir on Basin Pond and two reservoirs on Codding Brook.
Drainage area: Basin Pond, 8.2 square miles; Codding Brook (upper), 0.67 square mile; Codding Brook (lower), 2.51 square miles.

Surface area of reservoirs: Basin Pond, very small; Codding (upper), 30 acres; Codding (lower), very small.
Water supplied by gravity.
Miles of pipe (1923): 18.9.
Services in use (1923): 777.
Meters in use (1923): 0.
Per cent of services metered (1923): 0.
Supply is guarded by rules and regulations of State Department of Public Health.

108. LEICESTER.

Owned by Cherry Valley and Rochdale Water District.
Introduced: 1911.
Source: Two dug wells near Henshaw Pond and filtered water of this pond.
Water pumped by fuel oil engine.
Miles of pipe (1922): 12.1.
Services in use (1920): 423.
Meters in use (1920): 100.
Per cent of services metered (1920): 24.
Supply is guarded by rules and regulations of State Department of Public Health.

109. LEICESTER.

Owned by Leicester Water Supply District.
Introduced: 1891.
Source: Dug wells.
Water supplied by gravity.
Services in use (1923): 238.

110. LENOX.

Owned by Lenox Water Company.
Introduced: 1875.
Population (1920): 2 691.
Source: Four reservoirs on Lenox Mountain (upper and lower Root Reservoirs, Ravine Reservoir and Woolsey Basin); Laurel Lake.
Drainage area: Laurel Lake, 3.3 square miles; Lower Root Reservoir, 1.15 square miles.
Surface area of reservoirs and lake: Upper Root Reservoir, 0.3 acre; Lower Root Reservoir, 10 acres; Woolsey Basin, 0.75 acre; Ravine Reservoir, 4 000 square feet; Laurel Lake, 0.25 square mile.
Water by gravity from reservoirs; pumped by electricity from Laurel Lake.
Miles of pipe (1923): 20.0.
Services in use (1923): 354.
Meters in use (1923): 386.
Per cent of services metered (1923): 100.

111. LEOMINSTER.

Owned by City.
Introduced: 1873.
Population (1920): 19 744.
Source: Haynes, Morse, Fall Brook, and Distributing reservoirs.
Drainage area: Haynes Reservoir, 314.5 acres; Morse Reservoir, 165 acres; Distributing Reservoir, 737 acres; Fall Brook Reservoir, 1.45 square miles.

Surface area of reservoirs: Haynes Reservoir, 58 acres; Morse Reservoir, 13 acres; Distributing Reservoir, 4.5 acres; Fall Brook Reservoir, 83 acres.
Water by gravity.
Miles of pipe (1922): 61.8.
Services in use (1922): 3 641.
Meters in use (1922): 3 039.
Per cent of services metered (1922): 83.
Supply is guarded by rules and regulations of State Department of Public Health.

112. LEXINGTON.

See Metropolitan Water District.

113. LINCOLN.

Owned by Town.
Introduced: 1874.
Population (1920): 1 042.
Source: Sandy Pond.
Drainage area: 0.72 square mile.
Surface area of pond: 0.25 square mile.
Water pumped by electricity.
Miles of pipe (1923): 26.6.
Services in use (1923): 353.
Meters in use (1923): 13.
Per cent of services metered (1923): 4.
Supply is guarded by rules and regulations of State Department of Public Health.

114. LITTLETON.

Owned by Town.
Introduced: 1895.
Population (1920): 1 277.
Source: Tubular wells.
Water pumped by electricity.
Miles of pipe (1923): 9.1.
Services in use (1923): 234.
Meters in use (1923): 234.
Per cent of services metered (1923): 100.

115. LONGMEADOW.

Owned by Town.
Introduced: 1895.
Population (1920): 2 618.
Source: Reservoir on Cooley Brook, Springfield Water Supply. Chlorinator installed for Cooley Brook supply.
Drainage area: 0.45 square mile.
Surface area of reservoir: 2 700 square feet.
Water pumped by gasoline.
Miles of pipe (1920): 14.9.
Services in use (1920): 652.
Meters in use (1920): 644.
Per cent of services metered (1920): 99.

116. LOWELL.

Owned by City.
Introduced: 1872.
Population (1920): 112 759.
Source: Tubular wells along Merrimac River and Hale's Brook.
(Iron removal plant for wells along Merrimac River.)
Water pumped by steam.
Miles of pipe (1923): 167.3.
Services in use (1923): 15 311.
Meters in use (1923): 13 618.
Per cent of services metered (1923): 89.

117. LUDLOW.

Owned by Ludlow Manufacturing Associates.
Introduced: 1873.
Population (1920): 7 470.
Source: Springfield Water Supply.
Water supplied by gravity.
Miles of pipe (1922): 9.1.
Services in use (1922): 753.
Meters in use (1922): 945.
Per cent of services metered (1922): 100.
Supply is guarded by rules and regulations of State Department of Public Health.

118. LYNN.

Owned by City.
Introduced: 1871.
Population (1920): 99 148.
Source: Hawkes Pond, Breed's Pond, Walden Pond, Birch Pond, Saugus River, Emergency Supply from Ipswich River.
Drainage area: Hawkes Pond, 1.86 square miles; Breed's Pond, 1.07 square miles; Walden Pond, 1.75 square miles; Birch Pond, 0.68 square mile; Ipswich River, 43.12 square miles; Saugus River, 10.58 square miles.
Surface area of ponds: Hawkes Pond, 0.117 square mile; Breed's Pond, 0.325 square mile; Walden Pond, 0.375 square mile; Birch Pond, 0.128 square mile.
Water pumped by steam and electricity.
Miles of pipe (1922): 136.
Services in use (1922): 14 535.
Meters in use (1922): 11 250.
Per cent of services metered (1922): 77.
Supply is guarded by rules and regulations of State Department of Public Health.

119. MALDEN.

See Metropolitan Water District.

120. MANCHESTER.

Owned by Town.
Introduced: 1892.
Population (1920): 2 466.
Source: Tubular wells and dug well; Gravel Pond.
Drainage area of Gravel Pond: 0.20 square mile.
Surface area of pond: 0.072 square mile.

Water pumped by steam.
Miles of pipe (1923): 21.
Services in use (1923): 659.
Meters in use (1923): 652.
Per cent of services metered (1923): 99.

121. MANSFIELD.

Owned by Mansfield Water Supply District.
Introduced: 1888.
Population (1920): 6 255.
Source: Dug well.
Water pumped by steam.
Miles of pipe (1923): 29.5.
Services in use (1923): 1 449.
Meters in use (1923): 1 104.
Per cent of services metered (1923): 76.

122. MARBLEHEAD.

Owned by Town.
Introduced: 1885.
Population (1920): 7 324.
Source: Two dug wells and Thompson's Meadow Brook; tubular wells at Thompson's Meadow Brook; all filtered. (Filters designed for iron removal.)
Water pumped by steam and electricity.
Miles of pipe (1923): 42.
Services in use (1923): 2 000.
Meters in use (1923): 1 410.
Per cent of services metered (1923): 70.

123. MARION.

Owned by Town.
Introduced: 1908.
Population (1920): 1 288.
Source: Tubular wells.
Water pumped by electricity.
Miles of pipe (1923): 17.6.
Services in use (1923): 457.
Meters in use (1923): 182.
Per cent of services metered (1923): 40.

124. MARLBOROUGH.

Owned by City.
Introduced: 1883.
Population (1920): 15 028.
Source: Millham Brook Reservoir; Lake Williams.
Drainage area: Millham Brook Reservoir, 3.54 square miles; Lake Williams, 0.45 square mile.
Surface area: Millham Brook Reservoir, 66.8 acres; Lake Williams, 72.7 acres.
Water pumped by steam.
Miles of pipe (1923): 40.6.
Services in use (1923): 2 608.
Meters in use (1923): 2 171.
Per cent of services metered (1923): 83.
Supply is guarded by rules and regulations of State Department of Public Health.

125. MARSHFIELD.

Owned by Brant Rock Water Company.
Introduced: 1890.
Source: Two dug wells.
Water is pumped by fuel oil.
Miles of pipe (1923): 11.6.
Services in use (1923): 777.
Meters in use (1923): 0.
Per cent of services metered (1923): 0.

126. MARSHFIELD.

Owned by Humarock Water Company.
Introduced: 1900.
Source: Driven wells.
Water is pumped by fuel oil engine.

127. MATTAPOISETT.

Owned by Town.
Introduced: 1913.
Population (1920): 1 277.
Source: Tubular wells.
Water is pumped by electricity.
Miles of pipe (1923): 14.5.
Services in use (1923): 527.
Meters in use (1923): 0.
Per cent of services metered (1923): 0.

128. MAYNARD.

Owned by Town.
Introduced: 1889.
Population (1920): 7 086.
Source: White Pond.
Drainage area: 0.6 square mile.
Surface area of pond: 0.091 square mile.
Water is pumped by steam.
Miles of pipe (1923): 13.
Services in use (1923): 1 266.
Meters in use (1923): 1 254.
Per cent of services metered (1923): 99.
Supply is guarded by rules and regulations of State Department of Public Health.

129. MEDFIELD.

Owned by Town.
Introduced: 1889.
Source: Two dug wells.
Water pumped by electricity.
Miles of pipe (1923): 4.
Services in use (1923): 252.
Meters in use (1923): 0.
Per cent of services metered (1923): 0.

130. MEDFORD.

See Metropolitan Water District.

131. MEDWAY.

Owned by Town.
Introduced: 1911.
Population (1920): 2 956.
Water pumped by fuel oil.
Miles of pipe (1922): 13.
Services in use (1923): 600.
Meters in use (1923): 240.
Per cent of services metered (1923): 40.

132. MELROSE.

See Metropolitan Water District.

133. MERRIMAC.

Owned by Town.
Introduced: 1904.
Population (1920): 2 173.
Source: Tubular wells.
Water pumped by steam.
Miles of pipe (1923): 9.4.
Services in use (1923): 589.
Meters in use (1923): 34.
Per cent of services metered (1923): 6.

134. METHUEN.

Owned by Town.
Introduced: 1875.
Population (1920): 15 189.
Source: Tubular and dug wells along Spicket River, also tubular wells along Merrimac River. Chlorinators installed.
Water pumped by steam and electricity.
Miles of pipe (1923): 74.7.
Services in use (1923): 3 251.
Meters in use (1923): 2 960.
Per cent of services metered (1923): 91.

135. MIDDLEBOROUGH.

Owned by Middleborough Fire District.
Introduced: 1885.
Population (1920): 8 453.
Source: Dug well (iron removal plant).
Water pumped by electricity.
Miles of pipe (1923): 21.2.
Services in use (1923): 1 315.
Meters in use (1923): 1 243.
Per cent of services metered (1923): 95.

136. MIDDLETON.

See Danvers.

137. MILFORD (and Hopedale).

Owned by Milford Water Company.
Introduced: 1881.
Population (1920): 13 471.
Source: Three large dug wells; Charles River, filtered.
Water pumped by steam.
Miles of pipe (1923): 40.
Services in use (1923): 2 733.
Meters in use (1923): 2 622.
Per cent of services metered (1923): 96.

138. MILLBURY.

Owned by Millbury Water Company.
Introduced: 1895.
Population (1920): 5 653.
Source: Dug well; emergency supply, Singletary Pond (chlorinator).
Drainage area: Singletary Pond, 3.83 square miles.
Surface area of Singletary Pond, 356 acres.
Water pumped by electricity.
Miles of pipe (1923): 13.5.
Services in use (1923): 642.
Meters in use (1923): 18.
Per cent of services metered (1923): 3.

139. MILLIS.

Owned by Town.
Introduced: 1891.
Population (1920): 1 485.
Source: Dug wells.
Water pumped by steam.
Services in use (1920): 215.
Meters in use (1920): 80.
Per cent of services metered (1920): 37.

140. MILTON.

See Metropolitan Water District.

141. MONSON.

Owned by Town.
Introduced: 1895.
Population (1920): 4 826.
Source: Dug well and water from Ingall's Brook. Emergency supply from reservoir on Conant Brook.
Drainage area: Ingall's Brook, 0.75 square mile; Conant Brook Reservoir, 6.28 square miles.
Water supplied by gravity.
Services in use (1922): approx. 500.
Per cent of services metered (1922): approx. 50.

142. MONTAGUE.

Owned by Lake Pleasant Water Supply District.
Introduced: 1909.
Source: Summer supply from Turners Falls Fire District supply.
Miles of pipe (1922): 3.0.
Services in use (1922): 132.
Meters in use (1922): 132.
Per cent of services metered (1922): 100.
Supply is guarded by rules and regulations of State Department of Public Health.

143. MONTAGUE.

Owned by Turners Falls Fire District.
Introduced: 1887.
Source: Lake Pleasant.
Drainage area: 1.78 square miles.
Surface area of lake: 0.106 square mile.
Water is pumped by steam.
Miles of pipe (1922): 18.1.
Services in use (1922): 705.
Meters in use (1922): 44.
Per cent of services metered (1922): 6.
Supply is guarded by rules and regulations of State Department of Public Health.

144. MONTAGUE.

Owned by Miller's Fall Water Supply District.
Introduced: 1886.
Source: Turners Falls' supply.
Miles of pipe (1922): 5.95.
Services in use (1922): 300.
Meters in use (1922): 297.
Per cent of services metered (1922): 99.
Supply is guarded by rules and regulations of State Department of Public Health.

145. MONTAGUE (Village).

Owned by E. L. Bartlett.
Source: Springs.
Water supplied by gravity and hydraulic ram.
Miles of pipe (1918): 2.1.
Services in use (1918): 87.
Meters in use (1918): 0.
Per cent of services metered (1918): 0.

146. MONTEREY.

Owned by Monterey Water Company.
Introduced: 1917.
Population (1920): 282.
Source: Small reservoir on brook.
Drainage area: 0.18 square mile.
Surface area of reservoir: 600 square feet.
Water supplied by gravity.
Miles of pipe (1923): 1.2.
Services in use (1923): 27.

147. NAHANT.

See Metropolitan Water District.

148. NANTUCKET.

Owned by Wannacomet Water Company.
Introduced: 1878.
Source: Tubular wells; Wannacomet Pond.
Drainage area: 0.10 square mile.
Surface area of pond: 0.013 square mile.
Water pumped by steam and fuel oil.
Services in use (1923): 1 436.
Meters in use (1923): 0.
Per cent of services metered (1923): 0.

149. NANTUCKET (Siasconset).

Owned by Town.
Introduced: 1913.
Source: Tubular wells.
Water pumped by fuel oil.
Miles of pipe (1919): 5.
Services in use (1919): 164.

150. NATICK.

Owned by Town.
Introduced: 1874.
Population (1920): 10 907.
Source: Dug well.
Water pumped by steam and fuel oil.
Miles of pipe (1923): 60.9.
Services in use (1923): 2 925.
Meters in use (1923): 2 614.
Per cent of services metered (1923): 89.

151. NEEDHAM.

Owned by Town.
Introduced: 1890.
Population (1920): 7 012.
Source: Dug wells.
Water supplied partly by gravity; part pumped by steam.
Miles of pipe (1923): 42.6.
Services in use (1923): 1 996.
Meters in use (1923): 1 972.
Per cent of services metered (1923): 99.

152. NEW BEDFORD.

Owned by City.
Introduced: 1869.
Population (1920): 121 217.
Source: Great and Little Quittacas Ponds.
Drainage area: Great Quittacas, 11.42 square miles; Little Quittacas, 1.39 square miles.

Surface area of ponds: Great Quittacas, 1.81 square miles; Little Quittacas, 0.50 square mile.
Water pumped by steam and by electricity.
Miles of pipe (1923): 196.5.
Services in use (1923): 17 330.
Meters in use (1923): 16 780.
Per cent of services metered (1923): 97.

153. NEWBURYPORT.

Owned by City.
Introduced: 1881.
Population (1920): 15 618.
Source: Reservoir near Merrimack River, Jackman Basin, dug and tubular wells, and filtered water from two reservoirs on Artichoke River. (Slow sand filters.)
Drainage area of lower reservoir: 6.0 square miles.
Surface area of lower reservoir: 175 acres.
Water pumped by steam and by electricity.
Miles of pipe (1923): 42.
Services in use (1923): 3 650.
Meters in use (1923): 109.
Per cent of services metered (1923): 3.
Supply is guarded by rules and regulations of State Department of Public Health.

154. NEWTON.

Owned by City.
Introduced: 1876.
Population (1920): 46 054.
Source: Tubular wells, dug well and collecting pipes. Emergency connections with the Brookline and Metropolitan water supplies.
Water pumped by steam.
Miles of pipe (1923): 168.2.
Services in use (1923): 10 700.
Meters in use (1923): 10 600.
Per cent of services metered (1923): 99.

155. NORTH ADAMS.

Owned by City.
Introduced: 1861.
Population (1920): 22 282.
Source: Notch Brook Reservoir, Beaman Reservoir, James Brook Reservoir, Broad Brook Reservoir; emergency summer supply from two tubular wells.
Drainage area: Notch Brook Reservoir, 2.50 square miles; Beaman Reservoir, 1.75 square miles; James Brook Reservoir, 1.51 square miles; Broad Brook Reservoir, 6.24 square miles.
Surface area of reservoirs: Notch Brook Reservoir, 12.4 acres; Beaman Reservoir, 46.5 acres.
Water from reservoirs by gravity; pumped by steam from wells.
Miles of pipe (1923): 48.2.
Services in use (1923): 3 444.
Meters in use (1923): 701.
Per cent of services metered (1923): 20.

156. NORTH ANDOVER.

Owned by Town.
Introduced: 1898.
Population (1920): 6 265.
Source: Great Pond; chlorinator installed.
Drainage area: 5.26 square miles.
Surface area of pond: 0.96 square mile.
Water pumped by steam.
Miles of pipe (1923): 48.1.
Services in use (1923): 1 345.
Meters in use (1923): 1 256.
Per cent of services metered (1923): 93.
Supply is guarded by rules and regulations of State Department of Public Health.

157. NORTH ATTLEBOROUGH.

Owned by Town.
Introduced: 1884.
Population (1920): 9 238.
Source: Two dug wells.
Water is pumped by steam.
Miles of pipe (1923): 28.5.
Services in use (1923): 1 550.
Meters in use (1923): 1 557.
Per cent of services metered (1923): 100.

158. NORTH BROOKFIELD.

Owned by Town.
Introduced: 1893.
Population (1920): 2 610.
Source: Doane Pond; North Pond.
Drainage area: Doane Pond, 1.40 square miles; North Pond, 0.31 square mile.
Surface area of ponds: Doane Pond, 0.048 square mile; North Pond, 0.11 square mile.
Water pumped by electricity.
Miles of pipe (1923): 9.7.
Services in use (1923): 562.
Meters in use (1923): 5.
Per cent of services metered (1923): 1.

159. NORTHAMPTON.

Owned by City.
Introduced: 1871.
Population (1920): 21 951.
Source: Three reservoirs on Robert Meadow Brook; Mountain St. Reservoir on Beaver Brook; Intake Reservoir on Avery Brook.
Drainage area: Mountain St. Reservoir, 0.75 square mile; Avery Brook Reservoir, 7.53 square miles; Roberts (middle) Reservoir, 10.5 square miles.
Surface area of reservoirs: Mountain St. Reservoir, 72.9 acres; Avery Brook Reservoir, 0.14 square mile; Roberts (middle) Reservoir, 26 acres; Roberts (lower), 13 acres.

Water supplied by gravity.
Miles of pipe (1923): 84.
Services in use (1923): 4 000.
Meters in use (1923): 2 003.
Per cent of services metered (1923): 50.
Supply is guarded by rules and regulations of State Department of Public Health.

160. NORTHBOROUGH.

Owned by Town.
Introduced: 1882.
Population (1920): 1 753.
Source: Two reservoirs on Cold Harbor Brook.
Drainage area of Lower Reservoir, 2.36 square miles.
Surface area of reservoirs: Upper Reservoir, 8 acres; Lower Reservoir, 9 acres.
Water supplied by gravity.
Miles of pipe (1923): 13.3.
Services in use (1923): 458.
Meters in use (1923): 146.
Per cent of services metered (1923): 32.
Supply is guarded by rules and regulations of State Department of Public Health.

161. NORTHBRIDGE (Whitinsville).

Owned by Whitin's Machine Works.
Introduced: 1889.
Population (1920): 10 174.
Source: Driven wells and springs and Cook Allen Reservoir.
Drainage area: 1.22 square miles.
Surface area of reservoir: 10 acres.
Water pumped by electricity.
Miles of pipe (1923): 17.7.
Services in use (1923): 616.
Meters in use (1923): 33.
Per cent of services metered (1923): 5.

162. NORTHFIELD.

Owned by Northfield Water Company.
Introduced: 1900.
Population (1920): 1 775.
Source: Reservoir on Minot Brook.
Drainage area: 0.47 square mile.
Surface area of reservoir; 0.18 acre.
Water supplied by gravity.
Miles of pipe (1923): 1.7.
Services in use (1923): 94.
Meters in use (1923): 64.
Per cent of services metered (1923): 68.

163. NORTON.

Owned by Norton Water Company.
Introduced: 1912.
Population (1920): 2 374.
Source: Tubular wells.
Water pumped by fuel oil.
Miles of pipe (1923): 12.3.
Services in use (1923): 317.
Meters in use (1923): 18.
Per cent of services metered (1923): 6.

164. NORWOOD.

Owned by Town.
Introduced: 1885.
Population (1920): 12 627.
Source: Tubular wells; Buckmaster Pond (filtered).
Drainage area of Buckmaster Pond, 0.4 square mile.
Surface area of Buckmaster Pond: 29.5 acres.
Water pumped by steam and electricity.
Miles of pipe (1923): 31.9.
Services in use (1923): 2 224.
Meters in use (1923): 1 976.
Per cent of services metered (1923): 89.
Supply is guarded by rules and regulations of State Department of Public Health.

165. OAK BLUFFS.

Owned by Cottage City Water Company.
Introduced: 1890.
Population (1920): 1 047.
Source: Intercepted ground water from Beach Grove Springs.
Water pumped by steam.
Miles of pipe (1923): 23.9.
Services in use (1923): 1 384.
Meters in use (1923): 21.
Per cent of services metered (1923): 2.

166. ORANGE.

Owned by Town.
Introduced: 1873.
Population (1920): 5 393.
Source: Spring and reservoir on Coolidge Brook.
Drainage area: 1.38 square miles.
Surface area of reservoir: 1.0 acre.
Water pumped by steam.
Miles of pipe (1917): 17.0.
Services in use (1923): 929.
Meters in use (1923): 929.
Per cent of services metered (1923): 100.

167. OXFORD.

Owned by Oxford Water Company.
Introduced: 1906.
Population (1920): 3 820.
Source: Tubular wells.
Water pumped by fuel oil.
Miles of pipe (1923): 11.9.
Services in use (1922): 500.
Meters in use (1922): 369.
Per cent of services metered (1922): 74.

168. PALMER.

Owned by Palmer Fire District No. 1.
Introduced: 1920.
Source: Two reservoirs on Graves Brook; emergency supply from tubular wells.
Drainage area of Lower Reservoir: 0.5 square mile.
Surface area of reservoirs: Upper, 4 acres; Lower, 1 acre.
Water supplied partly by gravity; partly pumped by electricity.
Miles of pipe (1923): 10.
Services in use (1923): 548.
Meters in use (1923): 240.
Per cent of services metered (1923): 44.

169. PEABODY.

Owned by City.
Introduced: 1899.
Population (1920): 19 552.
Source: Brown and Spring ponds, Reservoir on Tapley Brook, Suntaug Lake, Cedar Pond, Goldthwaite Brook.
Drainage area: Spring Pond, 0.492 square mile; Suntaug Lake, 0.570 square mile; Tapley Brook Reservoir, 0.320 square mile; Cedar Pond, 0.800 square mile; Goldthwaite Brook, 1.730 square miles.
Surface area of ponds and reservoir: Spring Pond, 0.099 square mile; Suntaug Lake, 0.240 square mile; reservoir, 0.025 square mile; Cedar Pond, 0.070 square mile.
Water pumped by steam.
Miles of pipe (1923): 55.
Services in use (1923): 3 316.
Meters in use (1923): 2 886.
Per cent of services metered (1923): 87.
Supply is guarded by rules and regulations of State Department of Public Health.

170. PEPPERELL.

Owned by Town.
Introduced: 1909.
Population (1920): 2 468.
Source: Tubular wells.
Water pumped by fuel oil.
Miles of pipe (1923): 23.
Services in use (1923): 601.
Meters in use (1923): 497.
Per cent of services metered (1923): 83.

171. PITTSFIELD.

Owned by City.
Introduced: 1855.
Population (1920): 41 763.
Source: Ashley Reservoir, Ashley Lake, Sackett Reservoir, Hathaway Reservoir, Mill Brook Intake Reservoir, Farnham Reservoir; emergency supply from Lake Onota.
Drainage area: Ashley Reservoir, 1.75 square miles; Ashley Lake, 0.55 square mile; Sackett Reservoir, 2.2 square miles; Hathaway Reservoir, 1.05 square miles; Mill Brook Reservoir, 1.17 square miles; Farnham Reservoir, 4.06 square miles; Lake Onota, 9.67 square miles.
Surface area of reservoirs: Ashley Reservoir, 4.49 acres; Ashley Lake, 110 acres; Sackett Reservoir, 0.86 acre; Hathaway Reservoir, 0.50 acre; Mill Brook Reservoir, 3.66 acres; Farnham Reservoir, 41.51 acres; Onota Lake, 665 acres.
Water from reservoirs by gravity; pumped by electricity from Lake Onota.
Miles of pipe (1923): 121.5.
Services in use (1923): 6 779.
Meters in use (1923): 570.
Per cent of services metered (1923): 8.
Supply is guarded by rules and regulations of State Department of Public Health.

172. PLAINVILLE.

Owned by Town.
Introduced: 1909.
Population (1920): 1 365.
Source: North Attleboro Water Supply.
Miles of pipe (1921): 6.8.
Services in use (1921): 227.
Meters in use (1921): 226.
Per cent of services metered (1921): 100.

173. PLYMOUTH.

Owned by Town.
Introduced: 1855.
Population (1920): 13 045.
Source: Little South Pond, Great South Pond, Lout Pond
Drainage area: Little South Pond, 0.24 square mile; Great South Pond, 1.39 square miles.
Surface area of ponds: Little South Pond, 0.11 square mile; Great South Pond, 0.47 square mile; Lout Pond, 0.029 square mile.
Water to low service by gravity; pumped by steam to high service.
Miles of pipe (1923): 57.5.
Services in use (1923): 2 776.
Meters in use (1923): 798.
Per cent of services metered (1923): 29.
Supply is guarded by rules and regulations of State Department of Public Health.

174. PROVINCETOWN.

Owned by Town.
Introduced: 1893.
Population (1920): 4 246.
Source: Tubular wells.
Water pumped by steam.
Miles of pipe (1923): 12.
Services in use (1923): 1301.
Meters in use (1923): 646.
Per cent of services metered (1923): 50.

175. QUINCY.

See Metropolitan Water District.

176. RANDOLPH (see Holbrook).

Owned by Town.
Introduced: 1888.
Population (1920): 4 756.
Source: Great Pond (joint supply with Holbrook). Chlorinator installed.
Drainage area: 3.44 square miles.
Surface area of pond: 157 acres.
Water pumped by steam.
Miles of pipe (1922): 40.
Services in use (1923): 2 233.
Meters in use (1923): 646.
Per cent of services metered (1923): 29.
Supply is guarded by rules and regulations of State Department of Public Health.

177. READING.

Owned by Town.
Introduced: 1891.
Population (1920): 7 439.
Source: Filter gallery and artesian wells near Ipswich River (iron removal plant).
Water is pumped by steam.
Miles of pipe (1923): 33.5.
Services in use (1923): 1 881.
Meters in use (1923): 1 889.
Per cent of services metered (1923): 100.

178. REVERE.

See Metropolitan Water District.

179. ROCKLAND.

Owned by Town.
Introduced: 1887.
Population (1920): 7 544.
Source: Great Sandy Bottom Pond (joint supply with Abington).

180. ROCKPORT.

Owned by Town.
Introduced: 1895.
Population (1920): 3 878.
Source: Cape Pond. Chlorinator installed.
Drainage area: 0.42 square mile.
Surface area of pond: 40 acres.
Water pumped by steam.
Miles of pipe (1905): 12.7.
Services in use (1923): 961.
Meters in use (1923): 26.
Per cent of services metered (1923): 3.
Supply is guarded by rules and regulations of State Department of Public Health.

181. RUSSELL.

Owned by Town.
Introduced: 1911.
Population (1920): 1 237.
Source: Reservoir on Black Brook.
Drainage area: 3.7 square miles.
Surface area of reservoir: 0.5 acre.
Water supplied by gravity.
Miles of pipe (1920): 8.
Services in use (1920): 227.
Meters in use (1920): 5.
Per cent of services metered (1920): 2.
Supply is guarded by rules and regulations of State Department of Public Health.

182. RUTLAND.

Owned by Town.
Introduced: 1896.
Population (1920): 1 743.
Source: Muschopauge Lake.
Drainage area: 0.6 square mile.
Surface area of lake: 0.09 square mile.
Water pumped by electricity.
Miles of pipe (1923): 7.5.
Services in use (1923): 145.
Meters in use (1923): 95.
Per cent of services metered (1923): 66.
Supply is guarded by rules and regulations of State Department of Public Health.

183. SALEM.

Owned by City.
Introduced: 1868.
Population (1920): 42 529.
Source: Wenham Lake, Longham Reservoir; emergency supply from Ipswich River. (Chlorinator installed at Ipswich River).
Drainage area: Wenham Lake, 2.53 square miles; Longham Reservoir, 3.28 square miles.

Surface area of lake and reservoir: Wenham Lake, 0.39 square mile; Longham Reservoir, 0.14 square mile.
Water from Wenham Lake, pumped by steam; from Ipswich River by electricity.
Miles of pipe (1923): 74.7.
Services in use (1923): 7 500.
Meters in use (1923): 817.
Per cent of services metered (1923): 11.
Supply is guarded by rules and regulations of State Department of Public Health.

184. SALISBURY.

Owned by Salisbury Water Supply Company.
Introduced: 1915.
Population (1920): 1 701.
Source: Two dug wells (ground about upper well flooded).
Water pumped by electricity; emergency, fuel oil.
Miles of pipe (1923): 16.4.
Services in use (1923): 1 042.
Meters in use (1923): 2.
Per cent of services metered (1923): 0.

185. SAUGUS.

Owned by Town.
Introduced: 1878.
Population (1920): 10 874.
Source: Lynn and Metropolitan water supplies.
Miles of pipe (1922): 84.
Services in use (1923): 2 264.
Meters in use (1923): 1 166.
Per cent of services metered (1923): 52.

186. SCITUATE.

Owned by Scituate Water Company.
Introduced: 1901.
Population (1920): 2 534.
Source: Tubular wells; pond on First Herring Brook, filtered mechanically; Beaver Dam Spring.
Drainage area: First Herring Brook, 4.2 square miles.
Surface area of First Herring Brook: 13 acres.
Water pumped by electricity and by fuel oil.
Miles of pipe (1923): 46.9.
Services in use (1923): 1 644.
Meters in use (1923): 11.
Per cent of services metered (1923): 1.

187. SHARON.

Owned by Town.
Introduced: 1885.
Population (1920): 2 467.
Source: Dug well and tubular wells.
Water pumped by steam and electricity.
Miles of pipe (1922): 23.
Services in use (1923): 604.
Meters in use (1923): 13.
Per cent of services metered (1923): 2.

188. SHEFFIELD.

Owned by Sheffield Water Company.
Introduced: 1897.
Population (1920): 1 435.
Source: Smith and Clark springs.
Water supplied by gravity.
Supply is guarded by rules and regulations of State Department of Public Health.

189. SHELBURNE.

Owned by Shelburne Falls Fire District.
Introduced: 1912.
Population (1920): 1 436.
Source: Intake Reservoir on Fox Brook; storage reservoir on Middle Brook.
Drainage area: Fox Brook Reservoir, 0.5 square mile.
Water supplied by gravity.
Miles of pipe (1922): 11.
Services in use (1922): 365.
Meters in use (1922): 365.
Per cent of services metered (1922): 100.

190. SHIRLEY.

Owned by Shirley Village Water District
Introduced: 1903.
Population (1920): 2 260.
Source: Large wells.
Water pumped by electricity.
Miles of pipe (1923): 8.6.
Services in use (1923): 274.
Meters in use (1923): 273.
Per cent of services metered (1923): 100.

191. SHREWSBURY.

Owned by Town.
Introduced: 1915.
Population (1920): 3 708.
Source: Tubular wells.
Water pumped by fuel oil.
Miles of pipe (1923): 13.4.
Services in use (1923): 623.
Meters in use (1923): 597.
Per cent of services metered (1923): 96.

192. SIASCONSET.

See Nantucket.

193. SOMERVILLE.

See Metropolitan Water District.

194. SOUTH HADLEY.

Owned by South Hadley Fire District No. 1.
Introduced: 1872.
Source: Storage reservoirs on Buttery Brook and Leaping Well Brook.
Drainage area: Buttery Brook Reservoir, 0.5 square mile; Leaping Well Brook Reservoir, 400 acres.

Surface area of reservoirs: Buttery Brook, 2.5 acres; Leaping Well Brook, 9 acres.
Water supplied by gravity.
Miles of pipe (1923): 10.1.
Services in use (1923): 584.
Meters in use (1923): 20.
Per cent of services metered (1923): 3.

195. SOUTH HADLEY.

Owned by South Hadley Fire District No. 2.
Introduced: 1911.
Source: Two dug wells and filter gallery.
Water pumped by electricity.
Miles of pipe (1923): 8.
Services in use (1923): 201.
Meters in use (1923): 206.
Per cent of services metered (1923): 100.

196. SOUTHAMPTON.

Owned by Mountain Spring Water Company.
Introduced: 1900.
Population (1920): 814.
Source: Four springs.
Water supplied by gravity.

197. SOUTHBRIDGE.

Owned by Southbridge Water Supply Company.
Introduced: 1880.
Population (1920): 14 245.
Source: Two reservoirs on Hatchet Brook (slow sand filters for filtration of surface water); emergency supply from two reservoirs on small brook.
Drainage area: Reservoir No. 3, 2.95 square miles; Reservoir No. 4, 2.43 square miles.
Surface area of reservoirs: Reservoir No. 3, 0.034 square mile; Reservoir No. 4, 0.105 square mile.
Water supplied by gravity.
Miles of pipe (1923): 25.
Services in use (1923): 1 548.
Meters in use (1923): 1 595.
Per cent of services metered (1923): 100.

198. SPENCER.

Owned by Town.
Introduced: 1883.
Population (1920): 5 930.
Source: Shaw Pond.
Drainage area: 0.6 square mile.
Surface area of pond: 0.12 square mile.
Water supplied by gravity.
Miles of pipe (1923): 16.5.
Services in use (1923): 916.
Meters in use (1923): 825.
Per cent of services metered (1923): 90.

199. SPRINGFIELD.

Owned by City.
Introduced: 1874.
Population (1920): 129 614.
Source: Borden Brook Reservoir and Intake Reservoir on Westfield Little River, filtered (modified slow sand). Impounding reservoirs in Ludlow and Belchertown.
Drainage area: Borden Brook Reservoir, 7.95 square miles; Intake Reservoir, Westfield Little River, 48.00 square miles; Ludlow system, 21.10 square miles.
Surface area of reservoirs: Borden Brook Reservoir, 213 acres; Ludlow Reservoir, 448 acres.
Water supplied by gravity.
Miles of pipe (1923): 258.
Services in use (1923): 18 318.
Meters in use (1923): 17 828.
Per cent of services metered (1923): 97.
Supply is guarded by rules and regulations of State Department of Public Health.

200. STOCKBRIDGE.

Owned by Stockbridge Water Company.
Introduced: 1862.
Source: Lake Averic; small reservoir on Bear Mountain. Chlorinator at Lake Averic.
Drainage area: 1.8 square miles.
Surface area: 0.062 square mile.
Water by gravity from Bear Mountain; pumped by electricity from Lake Averic.
Miles of pipe (1923): 11.1.
Services in use (1923): 410.
Meters in use (1923): 54.
Per cent of services metered (1923): 13.
Supply is guarded by rules and regulations of State Department of Public Health.

201. STOCKBRIDGE.

Owned by Hill Water Company.
Source: Springs.
Water supplied by gravity.
Miles of pipe (1922): 0.7.
Services in use (1922): 14.
Meters in use (1922): 0.
Per cent of services metered (1922): 0.

202. STONEHAM.

See Metropolitan Water District.

203. STOUGHTON.

Owned by Town.
Introduced: 1886.
Population (1920): 6 865.
Source: Filtered water from Muddy Pond.

Drainage area: 1.0 square mile.
Surface area of pond: 3 acres.
Water is pumped by steam.
Miles of pipe (1922): 33.3.
Services in use (1922): 1 631.
Meters in use (1922): 1 248.
Per cent of services metered (1922): 77.

204. SUNDERLAND.

Owned by Sunderland Water Company.
Introduced: 1883.
Population (1920): 1 289.
Source: Two springs and Saw Mill Brook.
Drainage area of Saw Mill Brook: 0.4 square mile.
Miles of pipe (1923): 4.9.
Services in use (1923): 112.
Meters in use (1923): 0.
Per cent of services metered (1923): 0.

205. SWAMPSCOTT.

See Metropolitan Water District.

206. TAUNTON.

Owned by City.
Introduced: 1876.
Population (1920): 37 137.
Source: Assawompsett and Elders ponds.
Drainage area: Assawompsett Pond, 13.17 square miles; Elders Pond, 0.53 square mile.
Surface area of ponds: Assawompsett Pond, 4.20 square miles; Elders Pond, 0.22 square mile.
Water is pumped by steam.
Miles of pipe (1923): 99.0.
Services in use (1923): 6 311.
Meters in use (1923): 5 540.
Per cent of services metered (1923): 88.
Supply is guarded by rules and regulations of State Department of Public Health.

207. TISBURY.

Owned by Town.
Introduced: 1887.
Population (1920): 1 275.
Source: Spring near Tashmoo Pond.
Water pumped by steam.
Miles of pipe (1923): 10.
Services in use (1923): 526.
Meters in use (1923): 2.
Per cent of services metered (1923): 0.

208. UXBRIDGE.

Owned by Town.
Introduced: 1879.
Population (1920): 5 384.
Source: Tubular wells and springs.
Water by gravity from springs; pumped from wells by electricity.
Miles of pipe (1923): 12.1.
Services in use (1923): 629.
Meters in use (1923): 554.
Per cent of services metered (1923): 88.

209. WAKEFIELD.

Owned by Town.
Introduced: 1883.
Population (1920): 13 025.
Source: Crystal Lake. Chlorinator installed.
Drainage area: 0.9 square mile.
Surface area of lake: 85 acres.
Water pumped by steam.
Miles of pipe (1923): 45.5.
Services in use (1923): 2 800.
Meters in use (1923): 2 700.
Per cent of services metered (1923): 97.
Supply is guarded by rules and regulations of State Department of Public Health.

210. WALPOLE.

Owned by Town.
Introduced: 1896.
Population (1920): 5 446.
Source: Tubular wells.
Water pumped by steam and by electricity.
Miles of pipe (1923): 33.3.
Services in use (1923): 1 230.
Meters in use (1923): 990.
Per cent of services metered (1923): 80.

211. WALTHAM.

Owned by City.
Introduced: 1873.
Population (1920): 30 915.
Source: Two dug wells near Charles River.
Water pumped by steam.
Miles of pipe (1923): 66.5.
Services in use (1923): 4 724.
Meters in use (1923): 4 897.
Per cent of services metered (1923): 100.

212. WARE.

Owned by Town.
Introduced: 1886.
Population (1920): 8 525.
Source: Dug well and tubular wells.
Water pumped by steam and by electricity.
Miles of pipe (1921): 13.4.
Services in use (1922): 955.
Meters in use (1922): 969.
Per cent of services metered (1922): 100.

213. WAREHAM.

Owned by Wareham Fire District.
Introduced: 1908.
Source: Tubular wells.
Water pumped by fuel oil.
Miles of pipe (1922): 5.8.
Services in use (1923): 313.
Meters in use (1923): 175.
Per cent of services metered (1923): 56.

214. WAREHAM.

Owned by Onset Water Company.
Introduced: 1894.
Source: Jonathan's Pond.
Drainage area: 0.23 square mile.
Surface area of pond: 15 acres.
Water pumped by steam.
Miles of pipe (1923): 16.8.
Services in use (1923): 150.
Meters in use (1923): 1.
Per cent of services metered (1923): 1.

215. WARREN.

Owned by Warren Water District.
Introduced: 1923.
Source: Tubular wells near Comins Pond.
Water pumped by fuel oil.
Miles of pipe (1923): 8.0.
Services in use (1923): 400.

216. WATERTOWN.

See Metropolitan Water District.

217. WAYLAND.

Owned by Town.
Introduced: 1878.
Population (1920): 1 935.
Source: Two reservoirs on Snake Brook.
Drainage area on Upper and Lower Reservoirs: 0.67 square mile.
Surface area of reservoirs: Upper Reservoir, 4.6 acres; Lower Reservoir, 7.6 acres.
Water supplied by gravity.

218. WEBSTER.

Owned by Town.
Introduced: 1881.
Population (1920): 13 258.
Source: Dug well and tubular wells; emergency supply from filter gallery near Lake Chaubunagungamaug.
Water pumped by steam.
Miles of pipe (1923): 26.7.
Services in use (1923): 1 424.
Meters in use (1923): 946.
Per cent of services metered (1923): 66.

219. WELLESLEY.

Owned by Town.
Introduced: 1884.
Population (1920): 6 224.
Source: Williams Spring Well; tubular wells.
Water pumped by electricity.
Miles of pipe (1923): 54.8.
Services in use (1923): 1 993.
Meters in use (1923): 1 993.
Per cent of services metered (1923): 100.

220. WEST BRIDGEWATER.

Owned by Town.
Introduced: 1911.
Population (1920): 2 908.
Source: Brockton Water Supply.
Miles of pipe (1917): 24.
Services in use (1920): 629.
Meters in use (1920): 435.
Per cent of services metered (1920): 69.

221. WEST BROOKFIELD.

Owned by Town.
Introduced: 1913.
Population (1920): 1 281.
Source: Tubular wells.
Water pumped by electricity.
Miles of pipe (1923): 6.1.
Services in use (1923): 216.
Meters in use (1923): 216.
Per cent of services metered (1923): 100.

222. WEST SPRINGFIELD.

Owned by Town.
Introduced: 1875.
Population (1920): 13 443.
Source: Reservoir on Black Brook (filtered, slow sand); emergency supply from Springfield Water Supply.

Drainage area: 2.6 square miles.
Water pumped by electricity.
Miles of pipe (1920): 45.
Services in use (1920): 2,259.
Meters in use (1920): 2 259.
Per cent of services metered (1920): 100.
Supply is guarded by rules and regulations of State Department of Public Health.

223. WEST STOCKBRIDGE.

Owned by East Mountain Water Company.
Introduced: 1873.
Population (1920): 1 058.
Source: Two springs.
Water supplied by gravity.
Miles of pipe (1923): 0.9.
Services in use (1923): 56.
Meters in use (1923): 29.
Per cent of services metered (1923): 52.

224. WESTBORO.

Owned by Town.
Introduced: 1879.
Population (1920): 5 789.
Source: Filter basin below Westboro Reservoir.
Drainage area: 1.05 square miles.
Surface area of Westboro Reservoir: 55 acres; Filter Basin, 5 acres.
Water by gravity.
Services in use (1923): 832.
Meters in use (1923): 740.
Per cent of services metered (1923): 89.

225. WESTFIELD.

Owned by City.
Introduced: 1874.
Population (1920): 18 604.
Source: Two reservoirs on Moose Meadow Brook and reservoirs on Tillotson and Japhet brooks.
Drainage area: Upper Moose Meadow Reservoir, 2.06 square miles; Lower Moose Meadow Reservoir (Tekoa), 2.7 square miles; Tillotson Brook, 6.0 square miles; Japhet Brook, 0.41 square mile.
Surface area of reservoirs: Upper Moose Meadow Reservoir, 38 acres; Lower Moose Meadow Reservoir, small; Tillotson Brook, 1.75 acres; Japhet Brook, small.
Water supplied by gravity.
Miles of pipe (1923): 58.1.
Services in use (1923): 2 667.
Meters in use (1923): 112.
Per cent of services metered (1923): 4.
Supply is guarded by rules and regulations of State Department of Public Health.

226. WESTFORD.

Owned by Westford Water Company.
Introduced: 1908.
Population (1920): 3 170.
Source: Tubular wells.
Water pumped by electricity.
Miles of pipe (1923): 9.2.
Services in use (1923): 432.
Meters in use (1923): 1.
Per cent of services metered (1923): 0.

227. WESTHAMPTON.

Owned by Westhampton Water Company.
Introduced: 1894.
Population (1920): 305.
Source: Three springs.
Water supplied by gravity.
Services in use: 25.

228. WESTON.

Owned by Town.
Introduced: 1896.
Population (1920): 2 282.
Source: Dug well and tubular wells.
Water pumped by electricity.
Miles of pipe (1923): 14.5.
Services in use (1923): 405.
Meters in use (1923): 355.
Per cent of services metered (1923): 88.

229. WESTWOOD (Islington).

Owned by Westwood Water Company.
Introduced: 1901.
Population (1920): 1 358.
Source: Tubular wells.
Water pumped by electricity.
Miles of pipe (1923): 2.0.
Services in use (1923): 158.
Meters in use (1923): 10.
Per cent of services metered (1923): 6.

230. WEYMOUTH.

Owned by Town.
Introduced: 1885.
Population (1920): 15 057.
Source: Great Pond.
Drainage area: 2.8 square miles.
Surface area of pond: 290 acres.
Water pumped by steam and electricity.
Miles of pipe (1923): 85.1.
Services in use (1923): 4 823.
Meters in use (1923): 2 624.
Per cent of services metered (1923): 54.
Supply is guarded by rules and regulations of State Department of Public Health.

231. WHITINSVILLE.

See Northbridge.

232 WHITMAN.

Owned by Town.
Introduced: 1883.
Population (1920): 7 147.
Source: Brockton Water Supply.
Miles of pipe (1920): 29.8.
Services in use (1920): 1 668.
Meters in use (1920): 1 453.
Per cent of services metered (1920): 87.

233. WILLIAMSBURG.

Owned by Town.
Introduced: 1903.
Population (1920): 1 866.
Source: Two reservoirs on Unquomonk Brook.
Drainage area: Lower Reservoir, 0.9 square mile.
Surface area of reservoirs: Upper Reservoir, 2.9 acres; Lower Reservoir, 0.3 acre.
Water supplied by gravity.
Services in use (1923): 230.
Meters in use (1923): 2.
Per cent of services metered (1923): 1.
Supply is guarded by rules and regulations of State Department of Public Health.

234. WILLIAMSTOWN.

Owned by Williamstown Water Company.
Introduced: 1859.
Population (1920): 3 707.
Source: Rattlesnake Brook, Sherman Spring and Cold Spring reservoirs.
Drainage area: Rattlesnake Reservoir, 0.53 square mile; Sherman Spring Reservoir, about 0.17 square mile; Cold Spring Reservoir, about 0.07 square mile.
Surface area of reservoirs: Rattlesnake, 0.46 acre; Sherman Spring, 3.27 acres; Cold Spring, 5 400 square feet.
Water supplied by gravity.

235. WINCHENDON.

Owned by Town.
Introduced: 1896.
Population (1920): 5 904.
Source: Two dug wells.
Water pumped by steam and electricity.
Miles of pipe (1923): 26.
Services in use (1923): 1 100.
Meters in use (1923): 1 050.
Per cent of services metered (1923): 96.

236. WINCHESTER.

Owned by Town.
Introduced: 1873.
Population (1920): 10 485.
Source: Three reservoirs.
Drainage area: North Reservoir, 0.51 square mile; Middle Reservoir, 0.44 square mile; South Reservoir, 0.30 square mile.
Surface area of reservoirs: North Reservoir, 0.092 square mile; Middle Reservoir, 0.127 square mile; South Reservoir, 0.090 square mile.
Water by gravity.
Miles of pipe (1920): 47.
Services in use (1923): 2 382.
Meters in use (1923): 2 382.
Per cent of services metered (1923): 100.
Supply is guarded by rules and regulations of State Department of Public Health.

237. WINTHROP.

See Metropolitan Water District.

238. WOBURN.

Owned by City.
Introduced: 1873.
Population (1920): 16 574.
Source: Tubular wells and filter galleries near Horn Pond; emergency supply from Horn Pond direct (chlorinator installed).
Water pumped by steam.
Miles of pipe (1923): 60.25.
Services in use (1923): 3 687.
Meters in use (1923): 3 331.
Per cent of services metered (1923): 90.

239. WORCESTER.

Owned by City.
Introduced: 1845.
Population (1920): 179 754.
Source: Four reservoirs on Kettle Brook, Lynde Brook Reservoir, Upper and Lower Holden Reservoirs, Kendall Reservoir and Pine Hill Reservoir.
Drainage area: Kettle Brooks No. 1, 1.002 square miles; No. 2, 0.569 square mile; No. 3, 0.722 square mile; No. 4, 1.805 square miles; Lynde Brook Reservoir, 2.921 square miles; Upper Holden Reservoir, 4.555 square miles; Lower Holden Reservoir, 0.676 square mile; Kendall Reservoir, 2.451 square miles; Pine Hill Reservoir, 6.899 square miles.
Surface area of reservoirs: Kettle Brook Reservoir No. 1, 0.007 square mile; No. 2, 0.048 square mile; No. 3, 0.058 square mile; No. 4, 0.186 square mile; Lynde Brook Reservoir, 0.206 square mile; Upper Holden Reservoir, 0.211 square mile; Lower Holden Reservoir, 0.089 square mile; Kendall Reservoir, 0.273 square mile; Pine Hill Reservoir, 0.720 square mile.
Water supplied by gravity.
Miles of pipe (1923): 334.8.

Services in use (1923): 24 134.
Meters in use (1923): 23 334.
Per cent of services metered (1923): 97.
Supply is guarded by rules and regulations of State Department of Public Health.

240 WORTHINGTON.

Owned by Worthington Fire District.
Introduced: 1911.
Population (1920): 409.
Source: Rice Springs and reservoir on Ward's Stream.
Water supplied by gravity.

241 WRENTHAM.

Owned by Town.
Introduced: 1908.
Population (1920): 2 808.
Source: Tubular wells.
Water pumped by electricity.
Miles of pipe (1923): 13.3.
Services in use (1923): 395.
Meters in use (1923): 212.
Per cent of services metered (1923): 54.

PROCEEDINGS.

February Meeting.

Boston City Club,
Tuesday, February 12, 1924.

The President, David A. Heffernan, in the chair.

Charles P. Pool, Sanitary Engineer, Division of Water Supplies, Foods and Drugs, New Hampshire State Board of Health, read a paper on "Random Notes on Sanitation in New Hampshire." Mr. A. L. Gammage and Mr. M. N. Baker took part in the discussion.

A paper on "Further Studies of Water Purification by Filters Charged with Aluminum or Ferric Hydroxide," was read by H. W. Clark, Chief Chemist, Massachusetts Department of Health. Messrs. A. L. Gammage, Allen Hazen, Robert Spurr Weston, and George C. Whipple made remarks on this subject.

A discussion on "Why the Applicant Should Pay the Actual Cost of Service Installations from Street Main to Meter," was opened by Theodore L. Bristol and participated in by Messrs. Henry V. Macksey, George A. Carpenter, F. F. Forbes, Hugh McLean, J. F. Sullivan, Stephen H. Taylor, S. A. Agnew, Allston F. Hart, Joseph A. Hoy, George A. King, A. R. Hathaway, Frank J. Gifford, and H. T. Gidley.

Adjourned.

March Meeting.

Boston City Club,
Tuesday, March 11, 1924.

The President, David A. Heffernan, presided.

The President. Since our last meeting we have lost by death our valued fellow member and treasurer, Frederic I. Winslow. At this time I will call on Mr. Sherman.

Mr. Charles W. Sherman. Mr. President and Members of the Association: The Association has up to this time been fortunate in not losing by death many of its active officers, — I believe only two in the Association's history. Twenty-five years ago, almost exactly, we lost our then treasurer, George E. Batchelder, the father of our friend and fellow member, George W. Batchelder.

Today we mourn the loss of our treasurer, Frederic I. Winslow, who died on the 21st of February. Mr. Winslow had been a member of this

Association for about thirty-two years. He was a very regular attendant at the meetings and was widely known and had the friendship of a very large percentage of our membership.

Mr. Winslow was in the City Engineer's office of Boston, assigned to water-department work, for the early part of his experience, lasting until about 1916 or 1917. During the war period he was Resident Engineer on the construction of the Victory Plant at Squantum, and after the war went to the Metropolitan Water Works as Division Engineer at the Framingham office, where he remained until the time of his death. He became treasurer of this Association in 1922, on the resignation of Lewis M. Bancroft.

I assume that, as usual, a committee will be appointed to prepare a suitable memoir of Mr. Winslow for publication. I suggest that the members stand for a moment in silent respect to his memory.

(*Everybody rises and stands in silence.*)

THE PRESIDENT. I will state that a committee has been appointed.

According to the new constitution, Section 1 of Article 7, "Nomination and election of officers," at this time we are to elect a nominating committee. The section reads as follows:

> "At the business meeting in March the Association shall elect a nominating committee of five members who shall report to the secretary, before the first day of June, a list of nominations for officers to be elected for the ensuing year. This report shall be printed and mailed by the secretary to the membership of the Association on or before June 15."

What is your pleasure?

On motion of Caleb M. Saville, duly seconded, it was voted that the President be directed to appoint a committee of five members to nominate officers for the ensuing year.

THE PRESIDENT. At this time I will call on the Secretary, who has an announcement to make in regard to the June outing.

SECRETARY GIFFORD. At the Executive Committee meeting this morning it was voted to hold the June outing at Plymouth, Mass., the date to be decided later by the special committee appointed. (*Applause.*)

Mr. Blackmer extended the invitation for the Association to come to Plymouth this June, and I think that is enough to be said on that question.

Again I want to call your attention to the Rochester Convention. The question was asked this morning where the headquarters were to be. They are at the Powers Hotel. Your Secretary would like to have the individual members write him suggestions as to how you would like to be reminded during the coming summer of this convention in the fall.

I had one suggestion today that three automobile routes be published. I forgot to ask the gentleman who proposed it where they would start from. I presume he meant from Boston. We might prepare routes from all over

the country. But if that meets with your approval I would like to have as many of you as can and will write me, offering suggestions as to what we ought to do at this next convention, assuring you that we will not accept them all.

Mr. Stephen De M. Gage, Chemist and Sanitary Engineer, Rhode Island State Board of Health, gave a talk, illustrated with the stereopticon, on "Swimming Pool Sanitation in Relation to the Public Water Supply." Messrs. Robert Spurr Weston, Frank A. Marston, Gordon M. Fair, George A. Sampson, and Arthur L. Gammage took part in the discussion.

A paper on "Current Practice in Charges for Automatic Sprinkler Service," was read by Mr. H. A. Burnham, Engineer and Special Inspector, Associated Factory Mutual Fire Insurance Companies. The discussion was participated in by Stephen H. Taylor, Theodore L. Bristol, George A. Carpenter, Samuel H. MacKenzie, John C. Chase, and E. J. Titcomb.

A topical discussion on "Control of Street Openings," was opened by the reading of a paper prepared by Henry A. Varney, Town Engineer, Brookline, Mass. This was followed by remarks by Messrs. Richard H. Ellis, Stephen H. Taylor, Henry T. Gidley, Fred L. Cushing, Henry V. Macksey, Joseph A. Hoy, and Roger W. Esty.

Adjourned.

BOOK REVIEW.

"ELEMENTARY HYDRAULICS."

By F. W. Medaugh, Instructor in Civil Engineering, The Johns Hopkins University. 144 pages, 71 illustrations. Price $2.00 net. D. Van Nostrand Company.

(*Reviewed by* FRANK A. MARSTON.*)

Investigations in the field of hydraulics have been made from time to time for many years, and yet it is only in recent years that material progress has been made in accumulating data of value for the solution of many problems encountered in this branch of engineering. There are still many phases of the subject that need to be cleared up and, therefore, any attempt to present even an elementary discussion of the principles involved, in a new or better manner, will be received with interest. The author expresses the hope "that the radically different methods which he has adopted in presenting some portions of the subject will justify the publishing of his manuscript."

The practicing engineer will find in this book an interesting presentation of the elements of hydraulics, discussed and illustrated in a way to refresh his memory and justify the time spent in the examination.

The water-works superintendent who would like to know something of the principles involved in the design and operation of many of the structures with which he has to deal, but yet who has not the time to turn the pages of the average textbook on hydraulics, will find in this little book a concise statement of the fundamentals he needs.

The book is of pocket size, easily carried, and printed in clear type, with clean-cut illustrations. The discussions are brief and free from long mathematical proofs.

Three chapters deal with water pressure, and the three following, with flow through pipes. These last will be of particular interest to water-works superintendents.

Short chapters on the Venturi Meter, the pitot tube, orifices and weirs, deal in an interesting way with these devices so useful in water-works practice. The instructions for the setting and use of weirs are particularly well written.

Two chapters discuss the hydraulic phases of short tubes and nozzles and flow in open channels. The last-named contains a simple diagram for the determination of V (velocity) by the Chezy formula.

The last chapter relates to the principles on which water wheels are designed.

The book closes with a series of problems designed for classroom use, but which are equally suitable for the engineer or superintendent having an investigating turn of mind.

Taken all together, the book is well written and deserves commendation because of its concise way of stating the elements of a most interesting and useful branch of science.

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* A partner of Metcalf & Eddy, Consulting Engineers, Boston, Mass.

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Yours truly,

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Specializing in Water Works
31 NORTH SQUARE
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Telephone, Richmond 1200

Hersey Disc Water Meter, H. F., illustrated, is a direct descendant of No. 76321 with refinements which the experience of 25 years have proved increase its accuracy, reliability and durability.

No. 76321's Record proves the correctness of Hersey Design which has remained the same for nearly 40 years —an indication of what you may expect.

100% Accurate
After twenty five years service

HERSEY ⅝ inch Disc Water Meter No. 76321 was recently protested by a property owner in a certain eastern city.* Records showed that this meter was manufactured in 1899 and had been reset June 2, 1916.

The suspected meter was removed from the owner's basement and placed on the city's Mueller Meter Tester. The scales registered 62.50 lbs. or 100% accurate when one cubic foot of water was passed through the meter with a ⅝ inch and a 1/16 inch stream discharge. No repairs had ever been made on this meter. Careful inspection showed that the meter was good for still more years of service.

The record of meter No. 76321 is typical of the service of all Hersey Water Meters. They are high quality automatic revenue computers that continue to register accurately after years of strenuous service.

*Name on request

6704

HERSEY Mark WATER METERS

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FROZEN!—but not damaged

Here is an actual photograph of a LAMBERT Frost-proof Meter which has been frozen to an extent that would put the ordinary meter completely out of commission.

This is made possible by a patented, non-corrosive yielding bolt device which allows the upper and lower casing, disc chamber and gear train to part without damaging the meter in any way. Five minutes' labor the only repair cost.

The expense and annoyance from frozen water meters can be eliminated for all time through the installation of the LAMBERT Frost-proof.

It has been proved that the LAMBERT is the easiest water meter to take apart and put together again as well as the simplest, most reliable and accurate.

If you are interested in other types of meters, we make one for every requirement.

THOMSON METER COMPANY

100-110 BRIDGE STREET BROOKLYN, N. Y.

LAMBERT FROST-PROOF METERS

A Trident for Every Service!

WHY are there more than two million TRIDENTS in service?

There is only one reason,—TRIDENTS are more continuously accurate, more durable, more economically maintained. They are the *best* meters. Don't stint quality — you need the best for *your* services!

Have you seen our latest development,—the Trident (enclosed) Gear Train?

NEPTUNE METER COMPANY

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WATER METERS

The TROPIC — An all-bronze Water Meter, with connection spuds attached to the lower case. Particularly designed for warm sections of the country.

TROPIC

ARCTIC

The ARCTIC — A frost-bottom meter, especially designed for cold sections of the country.

These two meters embody exactly the same mechanical features, the only difference being the changes necessary to provide a frost breaking feature in the Arctic.

Either of these meters will be equipped with a COMPLETELY ENCLOSED intermediate train RUNNING IN OIL, if desired.

Write or wire nearest office for full information.

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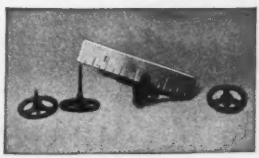
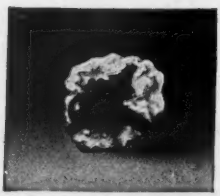
What Freezing Did Not Do

These two pictures show the intermediate gears of a Worthington Model "G" Meter. In one the train is encased in a solid block of ice, just as the parts were taken out of a completely frozen meter. After the ice melted the other photograph was made to show that no damage was done. Gears, train plate and casing, all came through the freezing totally unharmed. The only parts which suffered were four little bronze frost clamps, replaceable for a few cents. This shows some of the things that do *not* and *cannot* happen when a Worthington meter freezes. Those little frost clamps are certainly cheap insurance against the ravages of zero weather.

WORTHINGTON



Showing the gears, pinions and train plate after thawing. Not a single part has been warped or distorted in the least. The straight edge across the face of the train plate shows clearly that the original shape has not changed.



The intermediate train just after it was taken out of a standard Worthington meter. Note how completely the gearing is encased in ice.

WORTHINGTON PUMP AND MACHINERY CORPORATION

Executive Offices: 115 Broadway, New York City

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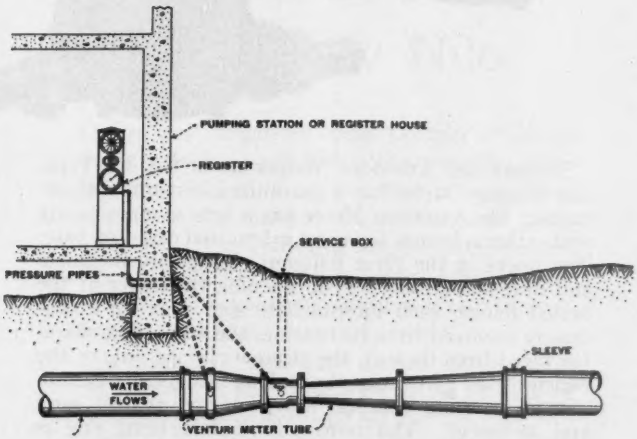
PRESENT CONSERVATION MEANS FUTURE DIVIDENDS

TO KNOW the day and night rates of water consumption per capita for each season of the year

TO KNOW the amount of abnormal demands on the system

TO KNOW the extent and time of occurrence of pipe line breaks and other wastage.

IS VITAL to a progressive water department.



Thousands of towns and cities are planning wisely for the future through the daily records from *Venturi* METERS on the main supply lines

Bulletin No. 209 tells more

BUILDERS IRON FOUNDRY PROVIDENCE, R. I.

"Builders of Venturi for 33 Years"

AMERICAN AND NIAGARA WATER METERS

5/8 INCH NEW AMERICAN WATER METER

5/8 INCH NEW NIAGARA WATER METER

Niagara and American Meters are of the disc type. The Niagara Meter has a galvanized cast-iron outside casing; the American Meter has a bronze main casing with either a bronze base or a galvanized cast-iron base. The works in the three different casings are the same and interchangeable. Upon opening the meter at the bolted flange, each intermediate gear may be immediately removed from its bearing, the measuring chamber lifted from its seat, the strainer slipped out, or the register tried by turning the stuffing box gear. All submerged working bearings are protected against sand and sediment. The hard rubber measuring disc is reinforced with a metal plate. Purchaser has option of round reading or straight reading register indicating cubic feet, U. S. gals., imp. gals. or litres.

Round Reading Register

Straight Reading Register

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ESTABLISHED 1892

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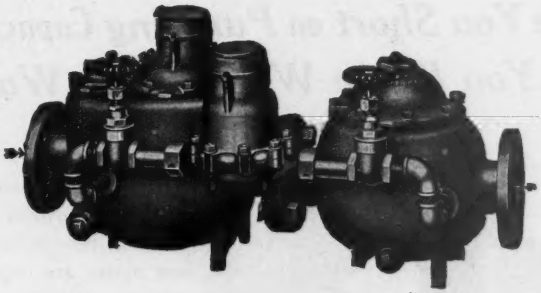

The New Nilo

The new improved **Nilo Compound Meter** now comes equipped with a bronze body. This is a valuable addition to meter service for it eliminates the danger of corrosion and filling up due to the collecting of corrosive matter. Bronze being stronger than iron the gross weight of the meter is less, making it easier to transport, handle and install.

It also has two gate valves which allow the removal of the by-pass meter for cleaning or repairing without shutting off the line.

The controlling valve mechanism of the new **Nilo Compound Meter** is self contained and easily detached from the main body casings.

These three improvements make the **Nilo,** a long standing favorite, the unrivaled leader in its field.

UNION WATER METER CO.

Incorporated 1868

WORCESTER, MASSACHUSETTS

Is Your Pressure Low?
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Do You Know Where Your Water Goes?

OUR Engineering Department will tell you how to determine your water distribution, how to find out whether or not new mains are required, etc. We can supply you with the means for: —

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6. Recording daily amounts of sewage handled and planning future extensions, etc., etc.

THE SIMPLEX METER

VENTURI, PILOT TUBE OR ORIFICE TYPES

THE importance of exact measurements by means of a Simplex Meter cannot be over emphasized. Mr. Jeffries, Chairman of the West Chester, Pa. Water Works Committee, was able, by checking the performance of his pumping engine with a Simplex Meter, to discover that due to the imperfection and wear in the valves the slippage amounted to 300,000 gallons of water per day. This represented a daily loss of $30.00, or in other words a daily saving of $30.00, or $900.00 per month, when the valves were put in order. The Simplex Meter thus paid for itself in a month's time.

Frequent repeat orders from satisfied customers who formerly used other meters are the best evidence of merit of the Simplex Meter.

We have had many years' experience in solving water flow problems involving all sorts of conditions, and we are at all times prepared to submit general layouts involving cost and capacity, and to make explicit and complete recommendations. Write for Bulletin N26.

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"WATCH DOG" WATER METERS

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DISC, CURRENT AND COMPOUND TYPES

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WATER METERS

WE MAKE ALL KINDS

ROTARY, AND OSCILLATING PISTON; VELOCITY; COMPOUND; VENTURI STYLE; AND

DISC

Our Nash Disc Meters have been on the market since 1888, and are now in use by thousands, all over the country, giving the best of service. There is no better disc meter than the

NASH TYPE K

All bronze construction, substantial, accurate and durable, with straight-reading register, and enclosed intermediate.

FROST PROTECTION

Nash Type K Meters have the best of all frost protection features. The two sections of the casing are held together by a patented, breakable flange washer. In event of freezing, these washers break at the flange, allowing both casing and measuring chamber to part, thereby protecting the working parts of the meter.

Send for fully descriptive circular No. 200.

NATIONAL METER COMPANY

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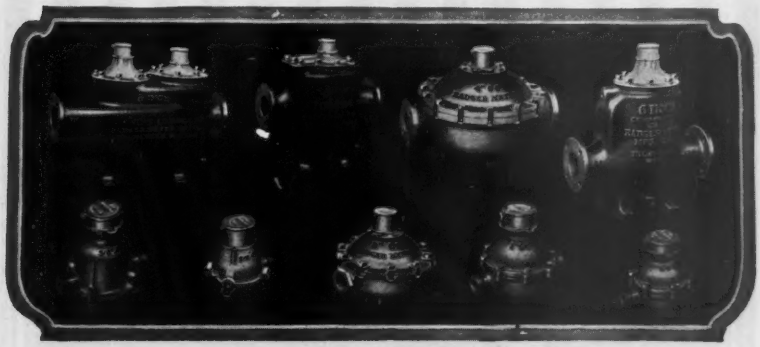

Make the Badger Meter your Standard for Comparison!

Just as you judge other equipment by standards — compare water meters with the Badger. Make it your **standard for comparison.** Point for point, base your rigid inspection on the outstanding construction advantages of the **Badger.** Be assured that the meter is **fit.** That it will **tick-off accurately.** That it will **register** an impartial tolling year after year. Don't accept less.

Badger Meters have long been highly reputed. Chiefly because they are built right. They are designed by practical water works engineers. All parts are readily accessible and made of such metals and materials that will not corrode, nor wear unduly. They are made for long life and service.

Let the Badger prove its dependability, accuracy and earning powers. Remember they are **faithful to the last drop.**

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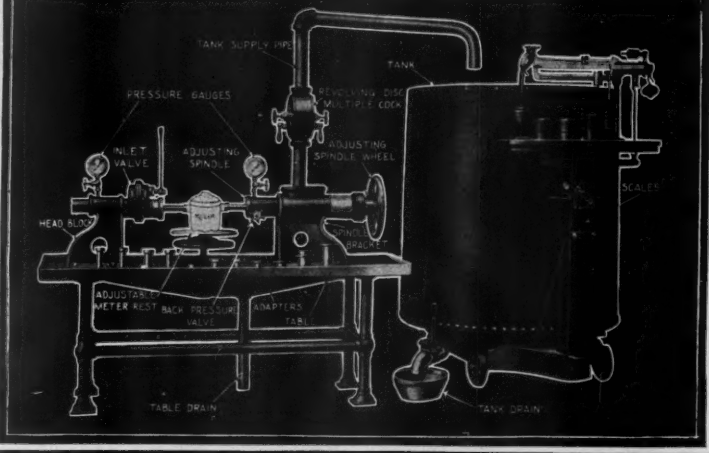
BADGER METERS

"Faithful to the last drop"



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Mueller Water Meter Tester

The Mueller will prove exactly what each meter does—will enable you to adjust each meter to absolute accuracy—will save more than its cost year after year. Used and endorsed by leading municipalities. The name Mueller guarantees both Quality and Service.

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First. — We make a specialty of furnishing Complete Water-Works Pumping Units of all types.

Second. — Total responsibility of installation is assumed by us.

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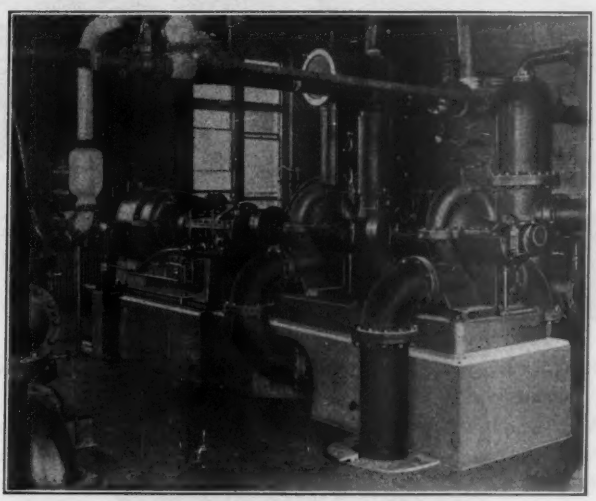

Turbine-driven Pump at the Arlington Station of the Metropolitan Water Works, Boston, Mass.

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Centrifugal Water Works Pumps

BUILT FOR THE LAST 70 YEARS AT BALDWINSVILLE, N.Y.

By Morris Machine Works

Reliable **Substantial** **Efficient**

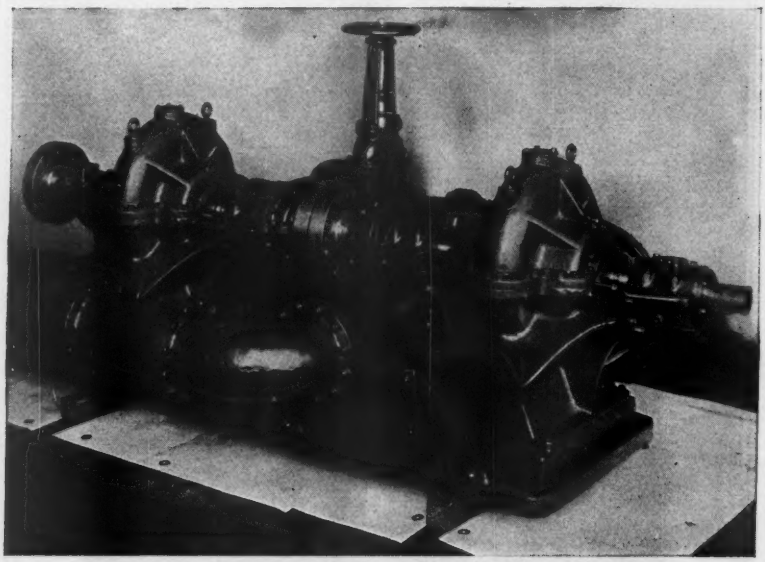

Illustration shows two 3 M.G.D. pumps just furnished as part of complete waterworks equipment to Kennebec Water District, Waterville, Me., to plans and specifications of Metcalf & Eddy, Consulting Engineers, Boston. These pumps will be driven by direct connected Motors and with Gasoline Engines for stand-by service. Arrangement permits single or series operation depending upon head, which varies greatly with capacity required.

We furnish pumps for all heads and capacities, motor turbine or engine driven, and when desired install complete units ready for operation.

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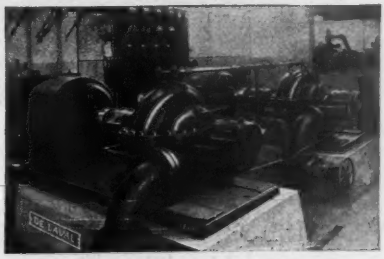

Typical Small Electrically Operated Centrifugal Municipal Water Works Installation.

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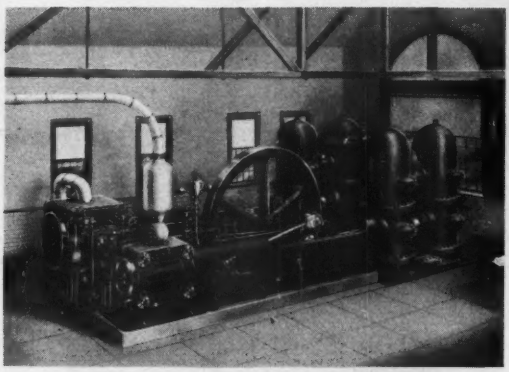

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Engineers, Iron Founders, Boiler Makers

Corliss and Una-Flow Engines

Water-Tube, Fire-Tube and Internal Furnace Boilers

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This indicates the paramount value of Chlorination in the protection of Public Water Supplies.

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Aluminum Sulphate

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Our location and shipping facilities place us in a position to offer insurpassable service and make us the logical source of supply for all filter plants in New England.

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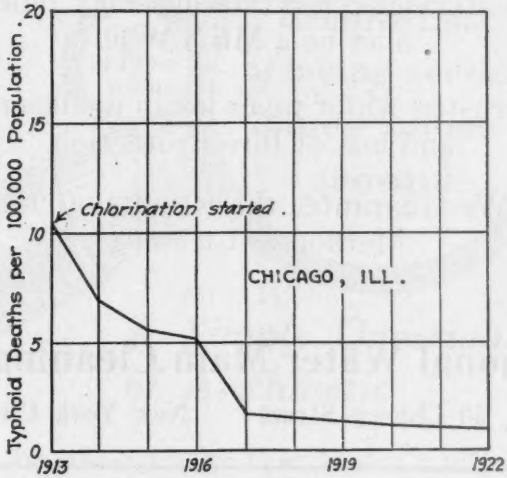

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ESTABLISHED 1848

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Incrusted water pipes mean inefficiency
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We Guarantee the Results of Our
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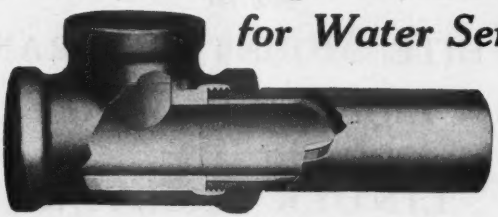

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Write us for details and prices.

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The cost of a length of service pipe is trifling compared with the cost of laying it. In case of failure of the pipe, the loss of water, labor of digging up and renewing a pipe, still further multiplies the installation cost.

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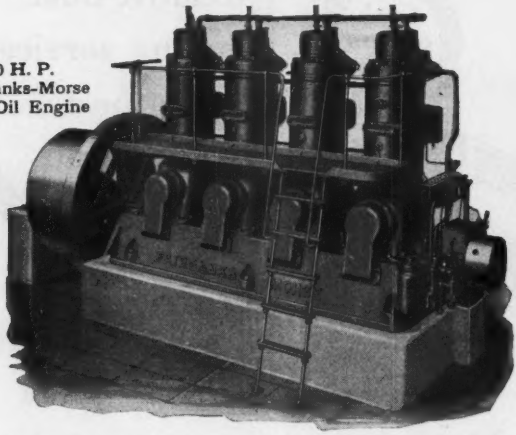
Over 90,000 H. P. in use

for Pumping only



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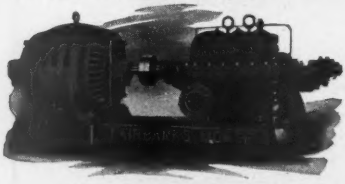

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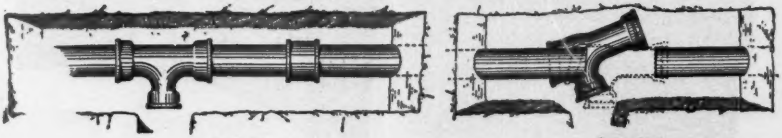

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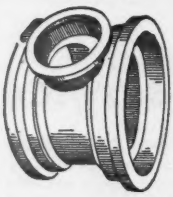

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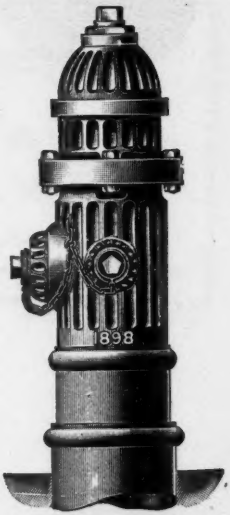

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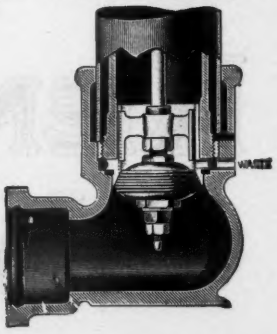
Number in use exceeds total of all other makes combined.



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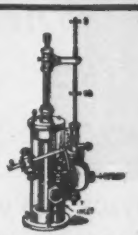

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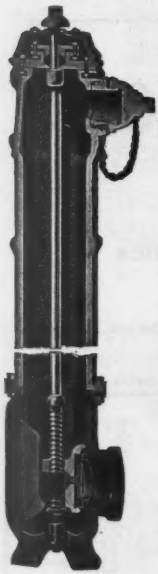

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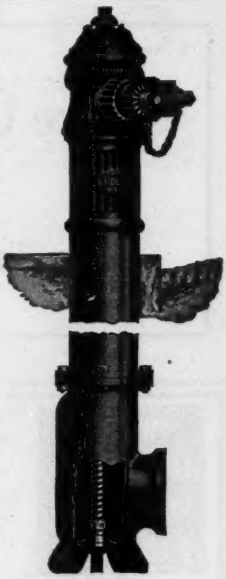
The drip is directly in the bottom of the hydrant and drains perfectly. It is protected by its valve, which never leaves its socket and cannot be clogged.



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BECAUSE this principle gives great power to open or close the gate just when it is needed, and speed in movement when power is unnecessary.

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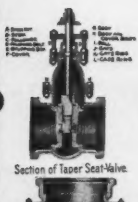
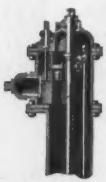
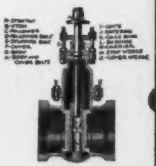


Section of Taper Seat-Valve.



Hydrant with Independent Nozzle Cut-off.



Section of Parallel Seat-Valve.

Section of Vertical Check-Valve.

Section of Vertical Foot-Valve.

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Hydrant with Water Crane Attachment.

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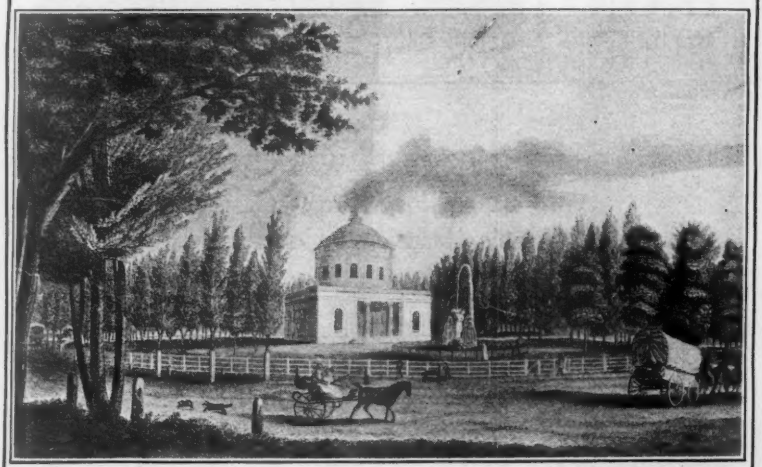
— "*American Notes*" *by Charles Dickens.*



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In 1842 Charles Dickens wrote the above description of the Philadelphia Water Works. At that time cast iron pipe, in Philadelphia, had been delivering water faithfully for 25 years. Nor was its usefulness nearly over. In 1915 the pipe illustrated was removed, though still in good condition after almost a century of service, to make way for a line of larger capacity.

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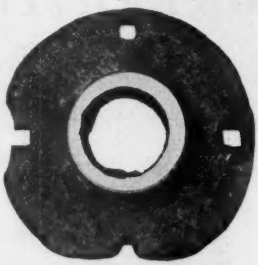

Section of 1817 line

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WATER & GAS PIPES
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for their service connections

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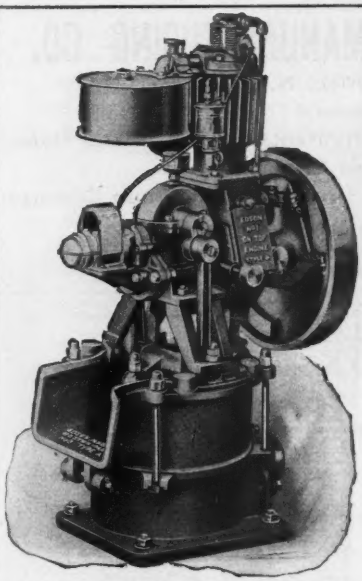

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Chadwick-Boston Lead Co.

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For overhead joints, or in wet places where the use of molten lead is not only impracticable but dangerous — **LEAD WOOL** may be used to advantage.

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TEN CENTS PER POUND PRICE TEN CENTS PER POUND PRICE TEN CENTS PER POUND TEN CENTS

Join Your Water Mains

WITH

LEAD-HYDRO-TITE

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AND CUT YOUR EXPENSES

50% FIRST COST

50% SMALLER BELL HOLES

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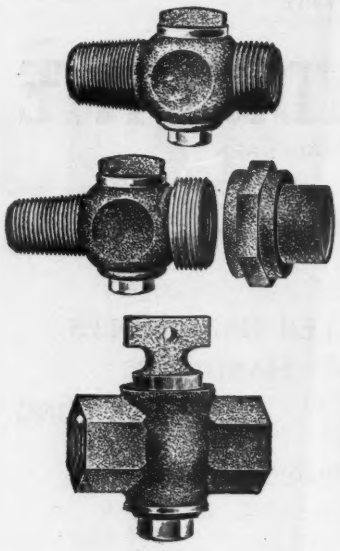

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Extension Service Boxes of proven advantages

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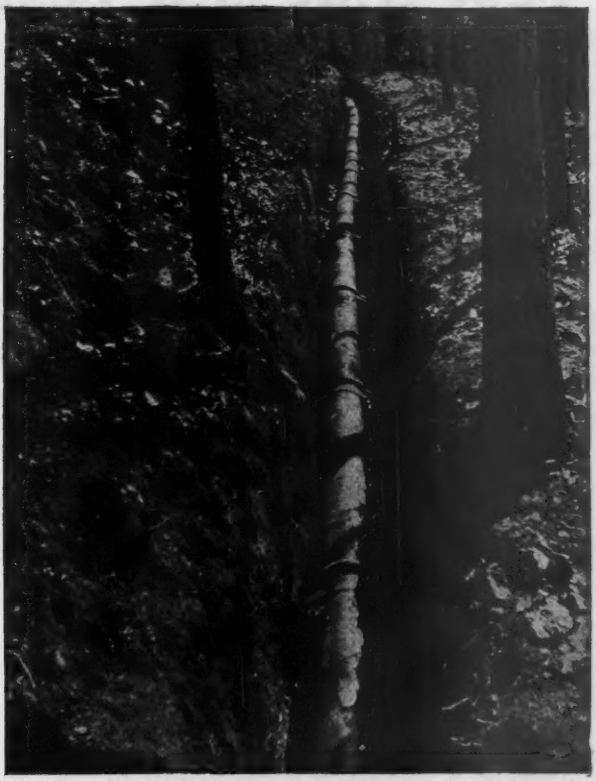

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giving perfect service
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no packing no calking no bell holes

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